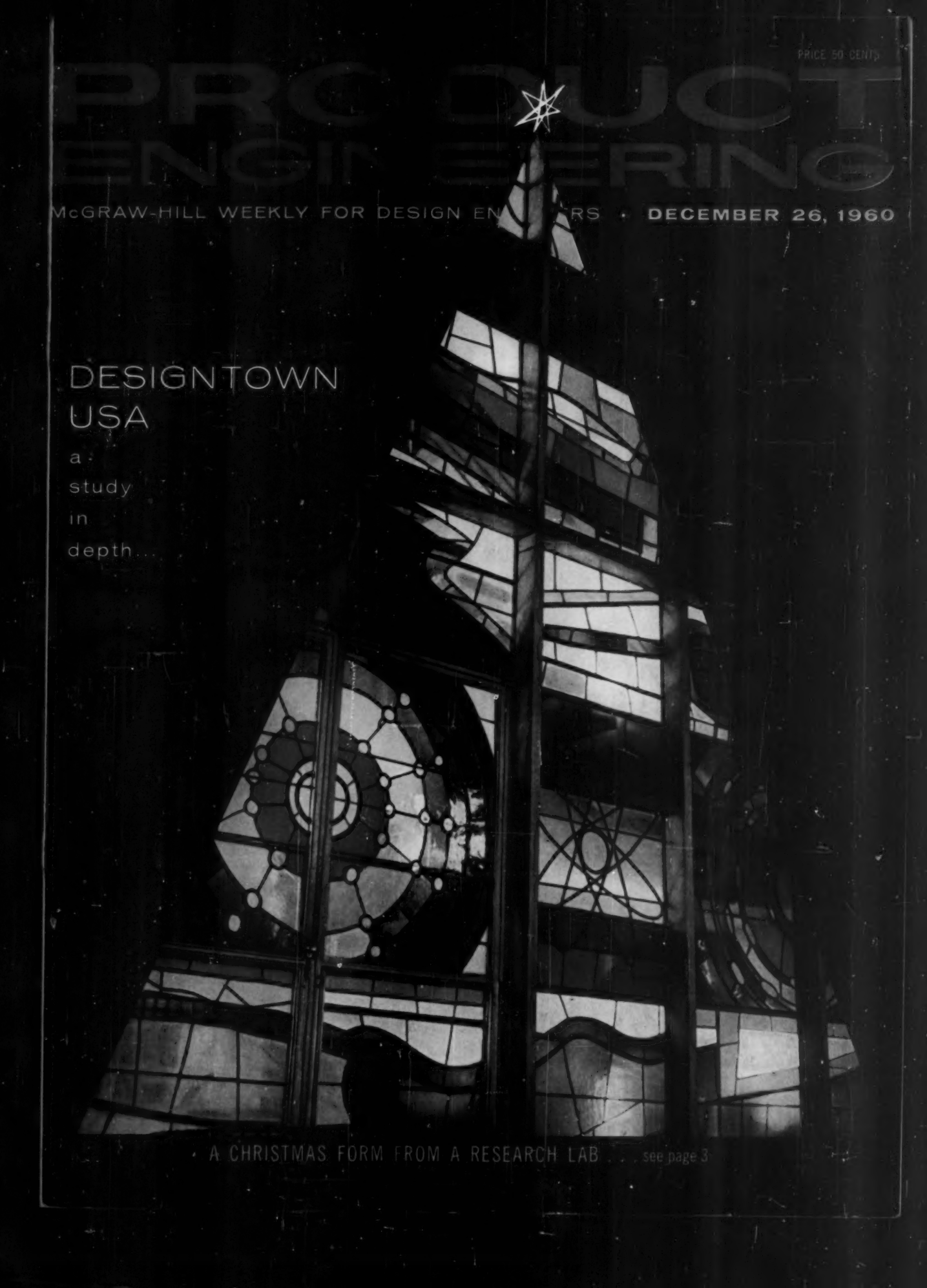
PRICE 50 CENTS

PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS · DECEMBER 26, 1960



DESIGNTOWN USA

a study in depth...

A CHRISTMAS FORM FROM A RESEARCH LAB . . . see page 3

ROTARY OR CENTRIFUGAL

...Which one is best for your application?

Rotary or centrifugal? Sometimes the choice is easy. For example, you would use a rotary pump for very viscous liquids (over 2500 s.s.u.). Or where poor suction conditions exist. Or when positive displacement is required. Centrifugal pumps would be used for extremely corrosive or abrasive liquids, low viscosity liquids (under 2500 s.s.u.) water, slurries, or petroleum products.

But . . . in many applications combinations of these factors exist. Or the liquid you want to pump is not clearly in either area. Then there are other considerations such as initial cost, operating cost, lubrication value of the liquid, location and even budget limitations.

All of these considerations can put you in the middle—where either a rotary or centrifugal can be used. The best choice can only be made by someone with experience and knowledge of both types.

As one of the few manufacturers of a complete line of both rotary and centrifugal pumps, Worthington can help you select the best, most economical solution to this perennial pump problem. For the name and address of your nearest Worthington representative, consult the yellow pages.

P.S. If you'd like a copy of a 50-page booklet, "Rotary and Centrifugal Pumps: Theory and Design," please write to Worthington Corporation, Section 20-14, Harrison, New Jersey, for bulletin G-2666.

WORTHINGTON

CIRCLE 201 ON READER SERVICE CARD

PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS

December 26, 1960 Vol. 31, No. 53

FEATURED:

DEPARTMENTS:

INTERESTING TO NOTE 3
COMING NEXT WEEK 4
DEVELOPMENTS TO WATCH 8
WHAT'S NEW IN RESEARCH 12
FROM WASHINGTON 13
THE ENGINEERING WEEK 15
APPEARANCE DESIGN 20
READER TO EDITOR 22
MEETINGS 23
WHY NOT R&D 24
HORIZONS 25
PRODUCT DESIGNS 47
SIGNIFICANT COMPONENTS 60
DESIGN LITERATURE 66
REPRINTS 73
ADVERTISERS INDEX 76
READER SERVICE CARDS 77

DESIGNTOWN, USA . . . J H Soltow
Is this what you're like?—a study in depth of the design engineer..... 27

SILICONE RUBBER MOLDS SHORT-RUN CASTINGS . . . H A Smith
Photo story shows 4 steps for casting quick, cheap parts 50

ACCELERATION TIME OF MOTORS . . . V B Honsinger
For special-duty cycles, these simple tests make choice easier..... 54

CALCULATIONS FOR STEEL TUBING . . . F Kaplan
Nomograph helps with answers: weight, annular area, shear strength... 57

CALENDAR GIVES FAST LOOK-AHEAD . . . O K Grade
One quick subtraction finds interval between two work-program dates... 59

FIELDS OF INTEREST REPRESENTED IN DEPARTMENTS:

MATERIALS:

Ignorance about metals may hold back supersonic transports..... 9
Glass fibers improve performance of cathode-ray tube..... 9
They're trying ternary alloys for new magnets..... 12
Metal screen converts LP gas to infrared..... 60

MECHANICAL:

New shape for retaining rings..... 8
Pneumatic actuator provides one-control choice of speeds..... 9
New data on thermal fatigue..... 12
Testing lags behind equipment design..... 12
Mobile arms move out of the lab..... 15
Five-hp transmission reverses in 0.2 sec..... 60

ELECTRICAL:

British developing piezoelectric transformers..... 8
Soviets developing insulating magnets in paste form..... 8
One generator thrives on other's waste energy..... 12
Clock motor runs 2 years on flashlight battery..... 60

PRODUCT DESIGNS:

Special-shape cams reduce speed smoothly..... 47
Pushbutton transmission has sure touch..... 48

GENERAL:

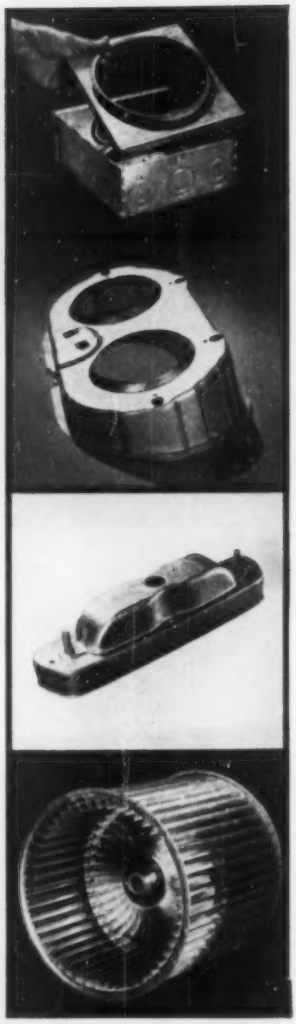
The chess-playing robot who beat Napoleon..... 3
Simulated space chamber speeds Air Force components tests..... 13

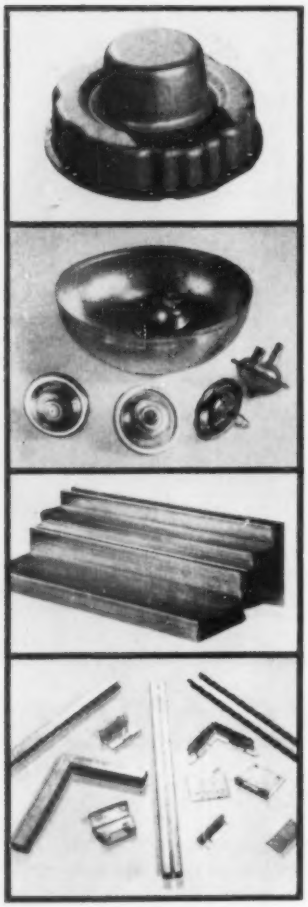
ARMCO STEELS / for better products • lower costs

Galvanized Steel

Armco ZINCGRIP Steel Protects Against Rust and Corrosion at Minimum Cost

Special hot-dip zinc coating that doesn't flake or peel gives formed steel parts economical durability.

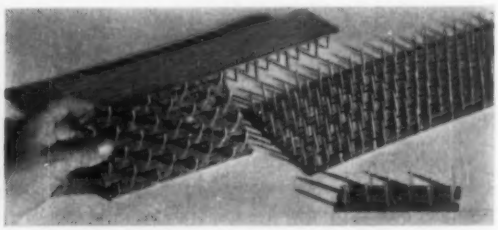




If you are making parts like these—parts that require the strength of steel yet must have low cost protection against rust—Armco ZINCGRIP Steel offers you opportunities to save money and improve product performance. Here's why:

* **ZINCGRIP STEEL has the lasting protection of a full-weight hot-dip zinc coating (1.25 oz. or heavier).**
* **The special coating on ZINCGRIP won't flake or peel despite forming, drawing, piercing, or other severe working.**
* **Armco's patented continuous process produces a zinc coating of uniform thickness and composition.**
* **For only a few cents' premium over cold-rolled steel, you eliminate the need for plating, painting or other protection.**
* **The economy and durability of ZINCGRIP STEEL has been service-proved in thousands of applications for more than 25 years.**

Let us send you complete information on Armco ZINCGRIP Steel so you can determine how its advantages can be most effectively used in *your* products. Armco Steel Corporation, 2370 Curtis Street, Middletown, Ohio.



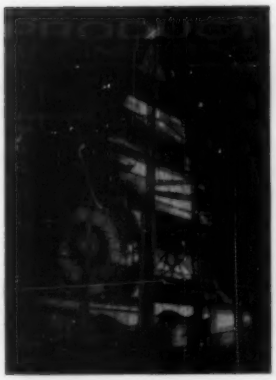
New steels are born at Armco

ARMCO STEEL

ARMCO

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation

INTERESTING TO NOTE



On our cover—a portion of the stained-glass window at the research center of Germany's famed Krupp Works, Essen, West Germany. PRODUCT ENGINEERING's art director, Dick Rooman, decided that the photographer's transparency of this window, trimmed in the shape of a Christmas tree, would provide a most appropriate seasonal cover.

The German motif is all the more appropriate at Christmas time because the idea of Christmas trees itself originated in Germany. In the 9th century, Saint Winifred traveled about Northern Germany preaching Christianity. One Christmas Eve, he came upon a group of people who had gathered about a huge oak tree to offer human sacrifice to their pagan gods. Legend says Saint Winifred balked this barbarism by sawing down the oak. As it fell, a tall young fir appeared in its place. This was hailed far and wide as a miracle. From that day forth, it became the custom for German families to gather about a tall evergreen on Christmas Eve.

Lights on the Christmas tree can be credited to another German, Martin Luther. It is said he was strolling through the countryside one Christmas Eve, awed by the beauty of the evergreen forest under the starry sky. When he came home, he tried to re-create the scene for his family by attaching some lighted candles to a small evergreen. These customs spread to the Scandinavian countries in the early 19th century, and from there to France and England. Records show that 35,000 Christmas trees were sold in Paris in 1890.

Actually, the evergreen was symbolic in religious rites even before the birth of Christ. Ancient Egyptians, when they observed the winter solstice, brought green palms into their homes as a symbol of "life triumphant over death." When the Romans celebrated the feast of Saturn, a part of the ceremony was the raising of an evergreen bough. Early Scandinavians also paid homage to the fir tree. To these people, the evergreen—tall and full when everything around it had succumbed to winter's frost—was enjoying special favor from the gods.

Hessian soldiers were the first to bring the idea of the Christmas tree to America. It was in this country that the custom of lighting trees in public places originated. Not only cities and towns, but the federal government as well, join in the display. Every December, for example, the Dept of Interior designates and lights a national Christmas tree.

The Mechanical Turk

Robots have appeared in the pages of science fiction for many decades and now have been accepted as commonplace. Today, they also have their place in the laboratory,

PRODUCT ENGINEERING

ELMER J TANGERMAN *editor*

STANLEY J ALLING *publisher*

ROBERT W CARSON *managing editor*
RICHARD M KOFF *assistant managing editor*

ROBERT E ABBOTT *senior associate editor*

JOHN KOLB *associate editor*
NICHOLAS CHIRONIS *associate editor*
FORD PARK *associate editor*
ROBERT PRENTISS *associate editor*
ANNESTA R GARDNER *associate editor*
WILLIAM GILMAN *associate editor*
FRANKLIN D YEAPLE *associate editor*
JOSEPH J KELLEHER *associate editor*
DOUGLAS C GREENWOOD *associate editor*

BENEDICT A LEERBURGER, JR *assistant editor*
DORA K MERRIS *assistant editor*
HERBERT KEE *assistant editor*
CHARLES J LYNCH *assistant editor*
FREDERICK MARICH *assistant editor*
JOHN PRICE *assistant editor*

FRANCIS E HALL *assistant editor*
BRUCE H FRISCH *assistant editor*
ANITA CAMERIK *assistant editor*

FELIX GIORDANO *Detroit*
SETH PAYNE *Washington*
WILLIAM WALLACE *Los Angeles*

RICHARD E ROOMAN *art director*
E K LOADER *associate art director*
ANGELA M GIACIN *assistant art director*

NORMA J VAN NESS *production supervisor*
LILLIAN M WITHAM *assistant supervisor*

ROBERT E BRUCKNER *consulting editor*
DOUGLAS GREENWALD *manager, economics services*

C C KANE *reader service manager*

McGraw-Hill News Bureaus

JOHN WILHELM *director*
MARGARET RALSTON *assistant*

GEORGE B BRYANT, JR *Washington*
DONALD MacDONALD *Detroit*
ARTHUR ZIMMERMAN *Cleveland*
STEWART W RAMSEY *Chicago*
JENNESS KEENE *San Francisco*
KEMP ANDERSON *Los Angeles*
RAY BLOOMBERG *Seattle*
B E BARNES *Atlanta*
MARVIN REID *Dallas*
JOHN TUNSTALL *London*
ARTHUR ERIKSON *Paris*
GENE DI RAIMONDO *Milan*
RAYMOND SHAH *Zurich*
CURT AGREN *Stockholm*
ERNEST CONINE *Moscow*
JIM MORRISON *Bonn*
FRED BAER *Vienna*
SOL SANDERS *Tokyo*
JOHN YAMAGUCHI *Tokyo*

A McGRAW-HILL PUBLICATION

December 26, 1960
Vol. 31, No. 53

Executive, Editorial, Circulation and Advertising Offices:
330 West 42nd St., New York 36, N. Y.
Telephone: LOngacre 4-3000
Teletype: TWX NY 1-1636
Cable Address: MCGRAW-HILL, NY

PRODUCT ENGINEERING is published weekly by McGraw-Hill Publishing Company, Inc. James H. McGraw (1860-1948), founder. UK subscription rates for individuals in the field of the publication, $3 per year, single copies 50 cents; Canadian subscriptions $5 per year; foreign $25 per year, payable in advance. Printed in Albany, NY; second-class postage paid at Albany, NY. Title ® registered at US Patent Office. © Copyright 1960 by McGraw-Hill Publishing Company, Inc. All rights reserved, including the right to reproduce the contents of this publication, either in whole or in part.

UNCONDITIONAL GUARANTEE. The publisher, on written request, agrees to refund the part of the subscription price applying to the remaining unfilled portion of the subscription if editorial service is unsatisfactory. PRODUCT ENGINEERING articles are indexed in both the Applied Science and Technology Index and the Engineering Index. PRODUCT ENGINEERING publishes its own semi-annual index. Copies are obtainable on request to the editor.
POSTMASTER Please send form 3579 to Fulfillment Manager, PRODUCT ENGINEERING, 330 W 42nd St., New York 36, NY.

as the news story on p 15 points out. Of all robots none was more sensational than the one that gulled people for more than eighty years—a mechanical man, seated behind a large cabinet, who played a commendable game of chess with challengers throughout the world.

This chess player, called "The Turk," was the creation of a German-born impresario, Johann Nepomuk Maelzel, who had made a reputation throughout Europe as a displayer of unusual music machines. It was in 1805 that he began exhibiting his marvelous new attraction. At first, Maelzel and the robot toured the European social circuit, playing chess against dukes and princes. Then in 1809, Napoleon challenged the robot to sit down with him. "The Turk" willingly accepted and quickly defeated the emperor in their first game. During the second encounter Napolean decided to test his robot partner and made a false move. "The Turk" responded by rapping on the table, shaking his head and returning the chessman to its original location. Napoleon repeated his false move and "The Turk" again responded with a rap, a head shake and a return of the chessman. When Napoleon made a false move the third time, "The Turk" reached across the table and swept Napoleon's pieces from the board. The astonished Napoleon exclaimed "C'est *juste*," replaced his chessmen, stuck to the rules—and lost.

In 1826, "The Turk" made his American debut. As in Europe, he fascinated his audiences and usually defeated his opponents. Newspapers and magazines tried to explain how the robot worked and most of them correctly assumed that a small man was concealed in the box. Before each contest, however, Maelzel would open the doors of the cabinet to reveal nothing but clear space, nuts, bolts and wheels. Actually, the box was built with trick panels and a false bottom so that a small man could conceal himself during Maelzel's introductory inspection. When all doors were shut, the hidden chess player could control "The Turk's" arms with levers, observing the board by looking at a duplicated board above his head. The chessmen were magnetized; so they raised or lowered little metal disks on the underside of the board when they were moved.

—Benedict A. Leerburger Jr

SIDELIGHT:

When our chief editor, Elmer Tangerman, published his report on engineering in the Soviet Union ("How Moscow Designs," July 14 '58) we received more than 150 letters offering comments and additional observations. One reader's letter aroused particular interest. He asked "Why describe how Moscow designs? Why not an American city?" Our reader had made a good point. So, on page 27 of this issue, PRODUCT ENGINEERING presents "Designtown, USA."

NEXT WEEK IN PRODUCT ENGINEERING

. . . **How to Solve Intricate Diecastings**

Their complexity requires adapting the usual casting procedure to special needs.

. . . **Ground Rules for Designing Sheetmetal Stampings**

Here's how to improve performance of parts; yet costs of initial tooling and tooling maintenance are less.

. . . **Spring Mechanisms—Force Analysis**

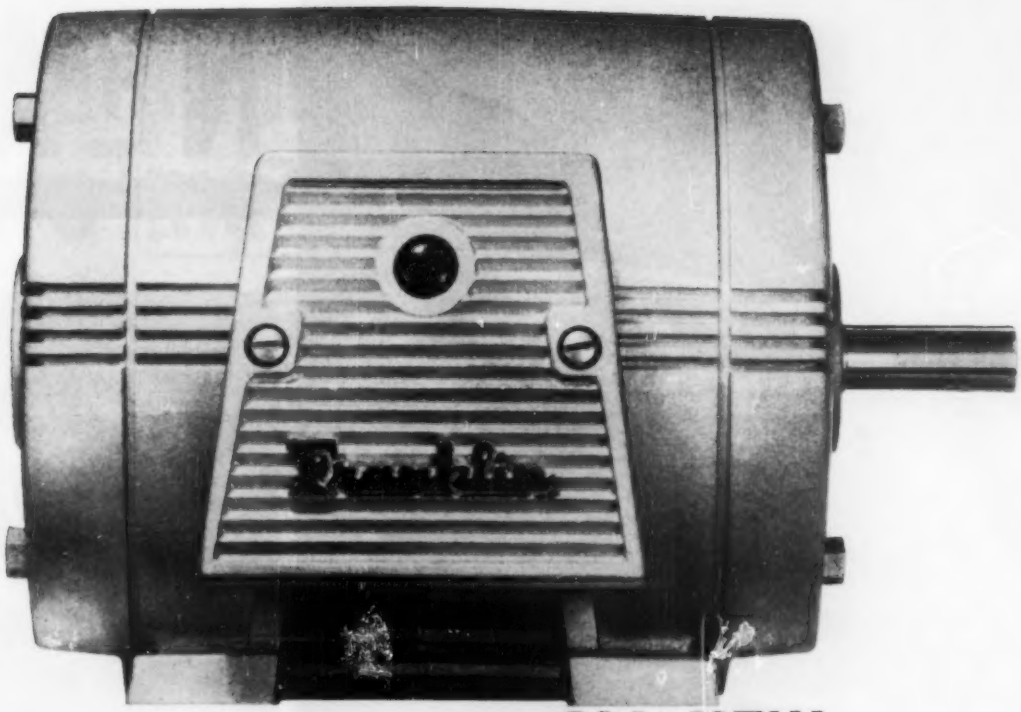
Mechanism proportions must be coordinated with choice of spring dimensions. These graphical methods minimize trial and error.

. . . **Graph Sets Safe Tolerances for Cumulative Dimensions**

When design keeps adding on dimensions, this graph will help establish an over-all tolerance that is neither too conservative nor too risky.

. . . **Edge-coded Cards—They Analyze Experimental Data**

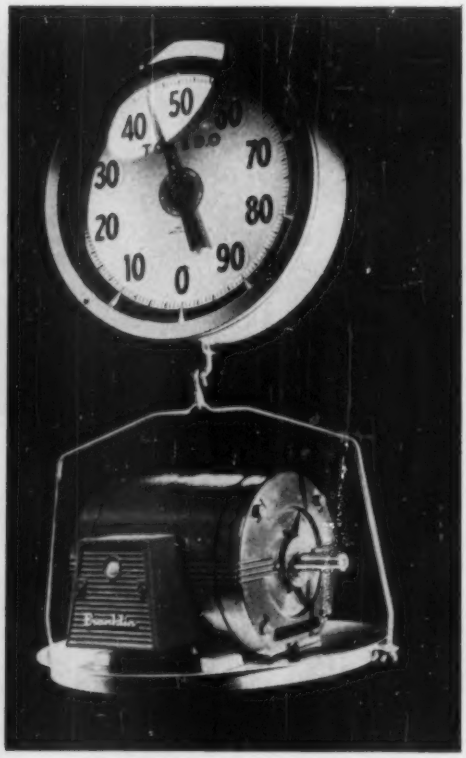
With them and two-variable graphs, you simply arrange results in the order you want, and the graphs plot themselves.



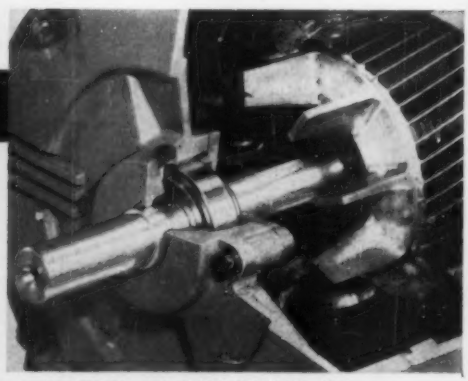
ALL NEW FRANKLIN STANDARD MOTORS WEIGH UP TO 30% LESS THAN ORDINARY INTEGRAL MOTORS

Read about this engineering accomplishment on the next two pages ... Also on the next page—news of a contest for design engineers only!!

NEW!



ALUMINUM CONSTRUCTION of the new Franklin motor gives the designer terrific weight advantages, plus faster heat dispersion and freedom from rust and corrosion. Strong, too.



PRELUBRICATED AND DOUBLE SHIELDED BEARINGS absolutely exclude all contaminants, eliminate the chief cause of motor bearing failure. Internal labyrinth seal keeps the grease in the bearings, out of the windings.

Franklin Integral Motors are made of Aluminum...

YET THEY'RE STRUCTURALLY STRONGER THAN COMPARABLE CAST-IRON MOTORS!

Here's news of a new, feather-weight motor you can apply *now* to your product.

Franklin Electric has designed an integral HP motor that gives you the light weight of aluminum . . . with a shock resistance greater than cast iron!

Aluminum frame, end-bells, rotor, and conduit box are combined to give you an average of *30% less weight* per motor rating.

You actually design weight *out* of your product by using this new, lighter motor. You'll need less bracing and support. And the Franklin lightweight is far easier to handle on your assembly lines. Less worker fatigue, faster assemblies. What's more, your shipping costs go down automatically with the over-all weight reduction!

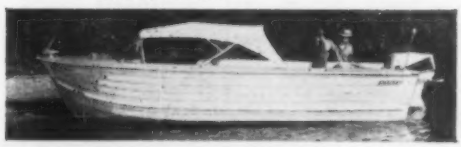
Aluminum has other advantages for you, too: greater thermal conductivity for cooler running, and a high resistance to rust and corrosion.

How many times could you have used these other Franklin features:

1. Pre-packed, double shielded bearings that absolutely exclude contaminants (chief cause of bearing failures in ordinary motors). There's an unusual labyrinth seal on the shaft that keeps grease in the bearings, not on the shaft. And a grease reservoir that practically eliminates the need for regreasing.
2. Quick-connect terminal board that arrives pre-connected to your specified voltage. No more taping and wiring. Terminal connectors make line connections in a matter of seconds.
3. Two-year guarantee from date of manufacture.
4. Inherent protector space *built-in* to the conduit box. The clean lines of this motor will stay clean. No add-ons.
5. Identical NEMA single and polyphase motor frame sizes. They're completely interchangeable, so you need carry no extra bases in stock.

And plenty more designer-requested features that can help you cut costs and increase the efficiency of your motor-driven product. For the complete story, just send in coupon below for a free, full-color brochure which explains this new motor line in detail. And while you're at it, enter the Franklin "Name the Aluminum Motor" contest explained below. Send in the coupon today.

Franklin® Electric Co., Inc.
BLUFFTON, INDIANA



Name the Aluminum Motor Contest... for Design Engineers only!

WIN A FULLY EQUIPPED STARCRAFT ALUMINUM BOAT AND EVINRUDE MOTOR!

Send your suggestion for a name for the all-new Franklin aluminum motor on the coupon at right. First prize—a 16 ft. Starcraft aluminum "Jupiter" runabout and a 40 h.p. Evinrude outboard motor. Twenty additional runner-up prizes of deluxe aluminum golf carts. Enter now, while the coupon is right in front of you. Here's all you have to do:

1. Send to Franklin Electric Company, Inc., your name suggestion, which reflects either a use or a feature of the motor. For example: OEM motor, Alumaline motors, etc. Send as many names as you please.
2. Prize winners will be chosen by an impartial panel of judges who are not employees of Franklin Electric Company, Inc.
3. Your entry must be in by February 28, 1961.
4. There's nothing to buy—just send your name suggestion.
5. That's absolutely all there is to it. In addition, your entry will automatically bring you a full-color informative brochure on the new Franklin aluminum motor.
6. Employees of Franklin Electric and its advertising agency are not eligible to participate as contestants. Contest offer not valid in states which prohibit such contests.

SEND YOUR ENTRY TO:
Franklin Electric Company, Inc.
Name-the-Aluminum Motor Contest
Bluffton, Indiana

Name _____ Title _____
Company _____
Address _____
City _____ State _____
Suggested name for the new Franklin motor:

_____ E

CIRCLE 7 ON READER SERVICE CARD

DEVELOPMENTS TO WATCH...

British developing piezoelectric transformers

Transformers that use a small bar of piezoelectric ceramic material in place of the usual windings and magnetic-field systems, and that can be operated at temperatures to 500 F, are being developed at Brush Crystal Co, Hythe, England.

The idea of using the piezoelectric effect in voltage-sensitive devices is not new; but, says Brush, satisfactory units could not be built with previously available piezoelectrics. Now, with new materials (notably the lead zirconate-titanate ceramics), transformers can be constructed that "complete favorably with conventional types in certain applications."

Several models have been built, including ring and transverse types.

The transverse-type piezoelectrics offer the most immediate promise. In a typical unit of this type, a bar of ceramic is coated on top and bottom surfaces, for one-half its length, with electrodes; and is polarized between these surfaces. The uncoated half is polarized transversely (across the width of the bar). Then, by applying an alternating voltage between the electrodes, the bar can be excited into a mechanical resonance along its length, producing a strain in the uncoated half which is transformed into a voltage appearing across electrodes attached at the ends.

For frequencies in the 40 kc/sec range, a bar 1¼ in. in length, is used. Input/output voltage ratios from 1:1 to 500:1 can be obtained.

Brush emphasizes the work is still in its early stages, but says initial results show considerable promise for generating high-voltage pulses.

Soviets developing insulating magnets in paste form

New magneto-dielectric materials are being developed at the Uzbek Academy of Sciences, a Soviet technical publication reports, by incorporating magnetic powders in synthetic-resin binders. The resulting "paste" can be used as a coating, or molded to shape before curing.

The pastes have low eddy-current losses, the Soviets say, and their magnetic permeability can be varied over a wide range. The materials are expected to be particularly useful in small electrical equipment. An English abstract of the Soviet report is contained in CIA publication T-49, available from OTS, Washington 25, DC as PB 131891.

(Note: More on flexible magnets in a major story next month.)

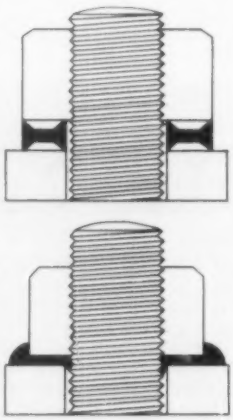
New shape for retaining rings

Plastic washers, with a double-convex (I-shape) cross-section, which squash down to fill and cushion the space between bolt and nut have been developed by Dubo-Borgringen of Holland for service under extreme conditions of shock and vibration. Made of nylon, they're said to be serviceable from −70 to 250 F under static loads and at least to 175 F under dynamic load. Resistant to most chemicals and oils, they can also serve as fluid seals.

Tests at the T.N.D. Institute of Delft indicate that maximum creep (45 microns for a bolt under a tensile stress of 5500 psi) is reached within 10 hr, and no further elastic after-effects could be detected so long as the temperature remained unchanged. An additional turn, when maximum temperature is reached, will compensate for thermal changes.

To go with the retaining rings, locking rings and a locking nut have also been designed. The rings are steel-toothed units that press into the plastic to provide metal-to-metal contact with the underlying surface; and the locknuts have a specially designed recess into which the plastic collar fits.

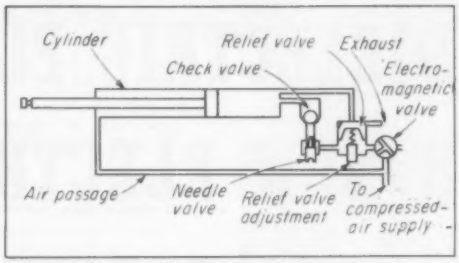
A 6-page summary (in English) of the Institute report on the retaining rings, and a comprehensive brochure (in Dutch), may be obtained from N. V. Dorned, Herengracht 331, Amsterdam, Holland.



INITIAL SHAPE of nylon rings is shown in upper diagram; compressed shape below. Note how material feeds in between threads as ring is seated.

Pneumatic actuator provides choice of speeds with one control

A door-actuating system in which a single pressure control, adjustable for different speeds in each direction, serves for both opening and closing, is being introduced by Establissements L. Faiveley of France. The company claims it's less expensive than other systems devised for similar purposes, and has a built-in, thrust-limiting safety device.



DIFFERENTIAL PISTON in actuator cylinder is so arranged that left half of chamber is supplied directly through lower air passage from compressed-air supply; inflow and outflow of air in right half is controlled by needle and relief valve.

The device consists of an actuator cylinder containing a differential piston and rod, checkvalve, needle valve, and an electromagnetically operated control valve (see diagram). Full line pressure is applied to the rod end of the cylinder at all times. The needle valve regulates the speed of emergence of the rod by throttling air through the checkvalve to the head end of the cylinder. Retraction of the rod is regulated by the outflow of air, controlled by the spring-operated relief valve, thus providing for independent adjustment of speed in each direction.

First application of the device, which has been patented, is in sliding doors for railway cars.

Ignorance about metals may hold back supersonic transports

We don't know enough about aluminum in aircraft to build a Mach 2 supersonic transport plane, R. J. Patton of Convair charges.

After all these years of building aluminum planes, critical data are still lacking—particularly in regard to strength and other properties after long exposure to high temperatures.

For instance, he says, there is no data on performance of aluminum alloys after exposure to 300 to 350 F for periods longer than 10,000 hr; and, since 30,000 hr is the minimum life expected of commercial transports, this is a big gap. Furthermore, Patton warns, the data now available for the shorter period were obtained mostly in connection with military fighter craft, and cannot readily be extrapolated into the commercial design area.

For steel, a likely candidate in Mach 3 transport design, the picture is much brighter, though some data for the longer periods are still lacking. (For titanium, the alternate material for Mach 3, long-term data are practically nonexistent.)

Patton's recommendation: modification of the B-58 (designed for cruising at Mach 1.5 and above) to produce a commercial-type plane that would provide the needed facts and figures.

Other aircraft companies are pushing the idea of jumping directly to Mach 3 and a steel plane. But all agree that plenty of research is needed—not only on metals but also on paints, lubricants, windshield and radome design and materials, instrumentation and communication.

Glass fibers improve performance of cathode-ray tube

Fiber faceplates can improve resolution of cathode-ray tubes by a factor of at least 5, says J. W. Hicks of Mosaic Fabrications Inc; and these new "fiber optics" light-piping devices should find a good many other applications in the field of photosensitive electron tubes.

The faceplates are made up of literally millions of tiny glass fibers (as small as 4 microns in dia), each serving to conduct and display the light it receives.

Faceplates for TV tubes are now going into production at Mosaic Fabrications, and other applications are expected to follow.

(Note: For background information on fiber optics, see *PE*—May 5 '58, p 6 and Apr 20 '59, p 14.) —ARG

From Monsanto FluiDesign Service...

DIELECTRIC FLUIDS FOR NEW ELECTRICAL AND ELECTRONIC USES

Monsanto can supply you with a series of dielectric liquids that offer the optimum combination of properties for liquid cooling and insulation. Many of the fluids described below are now used commercially in capacitors, transformers, "miniaturized" electronic packages, cables, amplifiers, solenoids, thermostats, computers, and circuit breakers.

Examples:

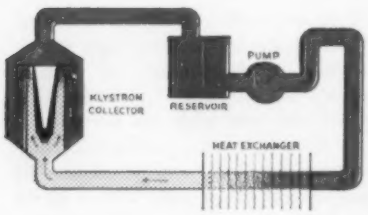
A. In electrical equipment such as transformers, Monsanto's askarel-type fluids offer a series of *fire-resistant* dielectrics. These fluids make a firesafe liquid-fill insulation for equipment that then may be located in operating areas without special precaution or costly shielding.

B. As impregnants for premium-quality capacitors, high dielectric Monsanto fluids permit a substantial decrease in capacitor size—about 50-60%—compared to oil-impregnated

Dielectric Fluids	OS-59	Coolanol® 35	Coolanol 45	Aroclor® 1221	Aroclor 1232	
Properties						
Dielectric Strength, 25°C, 60 cps, 0.1	44KV	47KV	27KV	35KV	35KV	
Dielectric Constant, 25°C, 1000 cps	2.46 (10^6cps)	....	2.2 (10^6cps)	4.5	5.4	
Volume Resistivity, ohm-cm, 25°C	6.7×10^{13}	....	9×10^{10}	$>5 \times 10^{12}$	$>5 \times 10^{12}$	
Power Factor, % 1000 cps, 25°C	0.006 (10^6cps)	....	0.4 (10^6cps)	<0.1	<0.1	
Viscosity, CS −65°F 100°F 210°F	 1380 6.8 2.2	 934 6.5 2.2	 2400 12.2 3.95	 .... 4.6 <1.8	 .... 6.9 <1.8	
Pour Point, °F	<−85	<−85	<−85	34	−32	
Boiling Point, °F 760 mm. Hg	>700	>600	>700	527	554	
Fire Point, °F Cleveland Open Cup	435	430	430	349	460	
Thermal Conductivity Btu/hr/ft/ft²/°F	0.077	0.079	0.080	0.067	0.063	
Specific Gravity @25°/25°C	0.88	0.89	0.89	1.18	1.26	
Coefficient Thermal Expansion, per °F	0.00046	0.00047	0.00048	0.00039	0.00040	

capacitors. Because their dielectric constants are closer to those from the capacitor paper itself, they help achieve a more evenly distributed dielectric stress than is possible with mineral oil.

C. Monsanto's coolant-dielectrics dissipate heat and operate liquid-cooled power packs, magnetrons, traveling wave tubes, klystrons with precise temperature control. Liquid cooling with these dielectrics permits miniaturization of electronic components, conserves size and weight. These special synthetic fluids are



also lubricants, and the single fluid can double as the hydraulic-fluid activator for tuning mechanisms as well as the coolant for the electronic unit.

This schematic circuit (at left) shows how Coolanol 45 liquid cools a klystron. Pumped around the collector, Coolanol 45 absorbs surface heat from the tube wall and carries it away for dissipation in the heat exchanger.

Check the fluids shown for application in equipment you are using or developing. Monsanto can supply you with a dielectric fluid for virtually any electrical or electronic application, can be most helpful in guiding you in the early design stages of equipment that will require a liquid dielectric.

A sample of the fluids shown will be sent to you for evaluation on request. Please specify the particular fluid that interests you and state the nature of the application so that pertinent details can be sent you. For further information on available fluids, request a copy of FluiDesign Service's FLUID DATA FILE.

Simply write on your company letterhead.

Monsanto

Monsanto Chemical Company
Organic Chemicals Division
FluiDesign Service, Dept. 2766B
St. Louis 66, Missouri

	Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260	Biphenyl	HB-40	Santowax® R
	35KV	35KV	35KV	35KV	35KV	35KV	35KV
	5.8	5.6	5.0	5.0	2.5	2.65	2.58
	$>5x10^{12}$	$>5x10^{12}$	$>5x10^{12}$	$>5x10^{12}$	$>1x10^{12}$	$>5x10^{13}$	$>1x10^{13}$
	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	.... 17.2 2.5	.... 45.3 3.2	.... 46.4 6.14	 75	.... 0.98	.... 29 3.9	....
	2	20	50	88	156	−13	293
	617	644	689	714	491	683	687
	>610	>640	>662	698	255	385	460
	0.058	0.057	0.054	0.051	0.076	0.072	0.063
	1.38	1.45	1.54	1.62	0.984	1.002	0.955
	0.00038	0.00039	0.00037	0.00037	0.00050	0.00041	0.00052

WHAT'S HAPPENING IN RESEARCH . . .

Try ternary alloys for new magnets

Iron-nickel-zinc alloys, produced by powder metallurgy techniques, show considerable promise as magnetic materials, though special precautions are needed in producing them because of zinc's volatility.

Iron-base materials, containing 5 to 35% each of zinc and nickel, prepared at Texas Engineering Experiment Station, showed saturation-induction values as high as 21,500 gauss, with best performance being scored by the alloys having the lower zinc percentages (below 15%) and low nickel content.

In coercive force, an alloy containing about 19 Zn-25 Ni scored highest —154 oersteds for precipitation-hardened material.

A report on the study, with recommendations for further research, has been prepared by P. S. Gupton. Information on it may be obtained from the Supervisor of Publications, TEES, College Station, Tex.

One generator thrives on other's waste energy

By combining thermionic and thermoelectric devices, says GE's Power Tube Dept, it is possible to get twice as much electricity from a given amount of heat. GE engineers have been experimenting with thermoelectric generators, operated on the waste heat from thermionic converters, and say they have achieved "significant boosts in both power output and efficiency."

The combination, called a "cascaded" device, takes advantage of the fact that thermionic systems (in which electrons "boiled" off a hot cathode are collected by a cold cathode) operate most efficiently at higher temperatures, while thermoelectric (thermocouple-type) devices can work at lower ones.

A developmental unit, using a commercial thermionic converter and a zinc antimonide–constantan thermocouple, with propane gas as the heat source, had an efficiency of 5 to 6%. But, says I. T. Saldi of GE, the hot-cathode temperature in this case was only 160°F. Efficiencies of 16% or more, he believes, can be obtained with a temperature in the 2400-F range.

(Note: for background information on these and other energy-conversion devices, see *PE*—May 4, '58, p 32).

New data on thermal fatigue

Discaloy (chrome-nickel-aluminum) steel, notched or unnotched, shows a longer fatigue life under thermal cycling than either hot-cold worked austenitic chrome-nickel-molybdenum (16-25-6) steel or A-286 (chrome-nickle-vanadium), R. W. and G. T. Smith of Lewis Research Center report. In unnotched tests, though, the 16-25-6 alloy outperformed A-286, while in notched-disk tests, the reverse was true.

They also found low-cycle fatigue life decreased whenever the plastic flow per cycle was increased, and this held true both for thermal cyling and for mechanical cycling at constant temperature.

In testing made at constant nominal strain, fatigue life was also found to be strongly influenced by mean stress, and alloys having the least tensile (or most compressive) mean stress at midpoint of the cycling test tended to show the longest fatigue life.

A report (TND-479), has been prepared and may be obtained from NASA.

Testing lags behind equipment design

Development of ultrahigh-pressure equipment is outpacing instrumentation for calibration and testing, says W. G. Field of the Air Force Electronics Research Directorate (Hanscom Field, Bedford, Mass). Confirming the Aerospace Industries survey of what's needed in pneumatic test equipment (*PE*—Nov 28, p 8), Field notes that several types of equipment capable of generating pressure in excess of 125,000 atmospheres and holding temperatures of 6500 F and more are now available, but "measurement procedures for such result lag well behind the development of high-pressure apparatus."

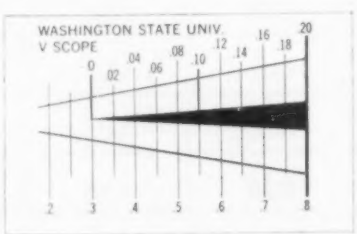
The broad potential of such equipment in thermodynamics, metallurgy, chemistry, crystallography, and electronics, he points out, should stimulate designers.

briefs . . .

More rare-earth metals are becoming available for research as High Purity Metals Inc, Hackensack, NJ (a subsidiary of Accurate Specialties Co) enters the field with this sextet: dysprosium, erbium, gadolinium, holmium, samarium, and ytterbium—all available in 25-gm units with a purity of better than 99%. (For information on properties and possible uses of these up-and-coming metals, see *PE*—Apr 25, p 39.)

An improved V-scope (sample below) has been designed for amplitude measurements by Arthur Hard of Washington State Institute of Technology Applied Mechanics Section (Pullman, Wash), and samples are available to anyone interested. It works on the basis of persistence of vision and the tendency of the eyes to concentrate more on a moving object than on a stationary one.

The scale is designed for attachment (by an adhesive backing) to the part being tested. As the object vibrates, the observer tends to see two black wedges instead of one, and the point at which they intersect, which can be read directly from the chart, gives the amplitude of the vibration. Small amplitudes can be read to an accuracy of 1/100 in. by noting the intersection of the black wedge itself. Larger amplitudes are read from the outer lines. Accuracy here is slightly less, but acceptable in most cases.



—ARG

FROM WASHINGTON . . .

Simulated space chamber speeds Air Force component tests

The largest space-environmental simulation chamber in the US is going into service at the Air Force's Arnold Engineering Development Center, Tenn. It will test the functioning of materials and components under space conditions

Top priority for chamber tests is the Air Force's ultrasecret SAMOS spy satellite. Engineers want to determine whether rocket engines for sending the satellite back to earth will ignite properly. Camera operations and other instruments going into the SAMOS will also undergo extensive tests in the chamber. The hope is to improve reliability of the satellite in the test chamber rather than through the more expensive method of test launchings.

An extensive program of testing new materials under space conditions is also planned for the new space chamber. **Simulated manned space experiments can be run in the facility, but these will be secondary to material and reliability tests.**

Navy rebuffs proposed Defense reorganization

A major revision of the Dept of Defense has been proposed to Pres-elect Kennedy. Prepared at Kennedy's request by a 6-man committee headed by Sen Stuart Symington (D-Mo), the report has evoked sharp criticism from the Navy.

Basically, the report aims to strengthen the power of the Secy of Defense while paring individual services' autonomy. For example, it calls for abolishing some 22 Assistant Secretary and Undersecretary positions in the Pentagon.

Navy foresees the plan as a means of bolstering the Air Force bid for a single service. And, as such, the admirals want no part of the plan. Navy brass has unleashed sharp criticism of the Symington plan, blasting it at every opportunity.

Industry shows mixed reaction to the measure. Theoretically, it would trim much of the red tape now entangling military contracts. But some industry representatives fear it would concentrate military business among a smaller segment of industry. Others say just the opposite.

Congress is sure to want long debates on the issue if Sen Kennedy tries to adopt the Symington plan when he becomes President. Forces are already being formed to both support and oppose the measure. **But few observers expect either Congress or Sen Kennedy to seek all proposed changes.**

New directory issued of missile ground-support equipment

New defense directory of missile ground-support equipment is now available. The third such directory to be published, it lists by service—Army, Navy and Air Force—all component parts used in ground-support equipment, and the name of the person responsible.

Titled "Technical Resources Directory—Missile Ground-support Equipment No 3, PB 161535," the 25-page directory was compiled by the Research and Engineering Office of the Dept of Defense. It may be obtained from Office of Technical Services, US Dept of Commerce, Washington 25, DC. Cost is 75¢.

Fuels proposed to combine advantages of solids, liquids

Future space and missile rockets may be designed to burn a mixture of solid and liquid fuels. That is what the experts are now predicting. Called hybrid fuels, they combine the advantages of both fuels and are potentially superior to either single type of fuel. Technologically the hybrids will soon be possible, the experts say.

A low-cost method of producing liquid hydrazine is reported by Aerojet-General. It entails producing hydrazine from nuclear reactors, a process that reportedly cuts the fuel's cost from around $2 lb to 25¢ lb.

Mr. Diserens (left) inspects a "Cronaflex" reduction with Robt. E. Thomas of Arrow Blue Company, Cincinnati Shaper Company's blueprinter.

60 YEAR OLD STORAGE PROBLEM SOLVED!

Versatile *Cronaflex*® Makes Possible Money-Saving Miniaturization Program

Finding a way to reorganize and consolidate a 60-year accumulation of engineering drawings posed a real problem for Cincinnati Shaper Company—until the firm learned of "Cronaflex"* Engineering Reproduction Films. As Chief Engineer Ralph Diserens tells it:

"By making reductions on 'Cronaflex' of all usable drawings, we've cut storage needs *75 per cent without the expense of costly new equipment or changes in present methods of operation.* The superior matte surface of 'Cronaflex' makes drafting on the reductions easy. And prints made from them are as easy to read as those made from originals —if not easier. The 'Cronaflex' reductions are also a lot more durable and take repeated handling without damage."

Cincinnati Shaper Co. has now standardized on "Cronaflex" for all its engineering reproduction requirements. They estimate that total savings in terms of reduced drafting time, lower print costs, improved shop efficiency and reclamation of drawings that would otherwise have to be retraced—all made possible by "Cronaflex"—will pay for the program in eighteen months.

Concludes Mr. Diserens: "Not only was 'Cronaflex' the perfect solution to our problem, it was the *only* workable one!"

Clip and mail the coupon *now* for further details on this miniaturization program or for more information on how "Cronaflex" can help you step up efficiency and cut costs.

** Du Pont's registered trademark for its engineering reproduction films*

DU PONT
REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

E. I. du Pont de Nemours & Co. (Inc.), Photo Products Dept. PE-12, Wilmington 98, Del.

I am interested in further information on:

☐ Miniaturization Program of Cincinnati Shaper Company

☐ The Full Line of "Cronaflex" Engineering Reproduction Films

Name_____

Firm_____

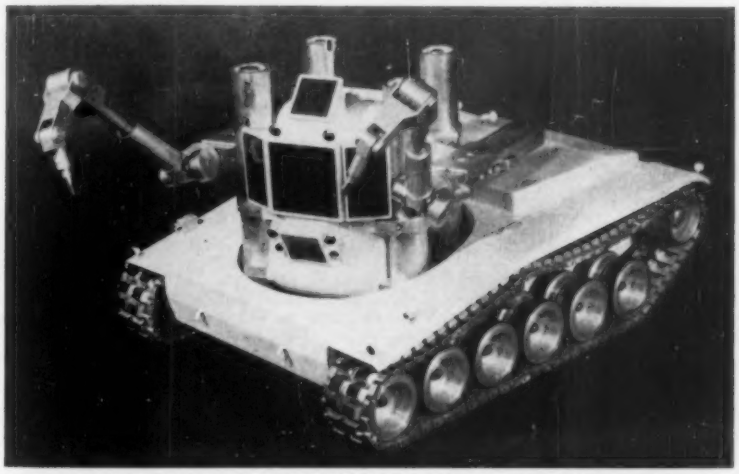
Address_____

City_____ Zone_____ State_____

THE ENGINEERING WEEK

Mobile Arms Move Out of the Lab—Go Under the Sea, Out into Space

Second generation of articulated arms are remotely controlled, can be programed to follow a sequence of actions. These characteristics free them for underwater and space exploration, servicing, and retrieval.



HEAVY SHIELDING AND AGILE MANIPULATORS characterize the Beetle—developed for servicing and maintaining nuclear aircraft engines. General Mills, better known for Wheaties, etc., designed the manipulators and General Electric planned the rest. The manipulators are reportedly capable of operating at temperatures ranging from —30 F to 120 F and at humidity from 0 to 100%—as well as in rain, dust, ice and snow. The unit has a specially designed control station for directing the nine variable-speed motions of the mechanical arms. The shoulder swings through a 180° arc and rotates; the upper arm rotates and extends 18 in.; the elbow rotates and swings through a 240° arc; the wrist rotates and swings through a 240° arc; the hand opens 5 in. and closes with a 250-lb grip.

NEW YORK—An unexpected legacy of the nuclear reactor program is birth of a small but brisk industry devoted to designing equipment for doing human work in an inhuman environment. Product planners of many nuclear-products divisions have recognized that grips and claws originally needed to lift and work on radioactive objects are readily adaptable to underwater missions, in dangerous factory areas—perhaps even in space.

The original robot-like devices were master-and-slave units—basically articulated claws, which through mechanical connection, duplicate the arm, wrist and finger movements of a human operator as he himself performs the motions. Now many of the units are remotely controlled mobile vehicles. An operator maneuvers the vehicle and its articulated arms from a control console, monitoring its movements by closed-circuit TV. Eventually, these mobile units may be completely free of human intervention, simply carrying out a complex computer or radio program. Such independent units may be needed for space exploration.

But robots are already having some programed sequences built into them, according to Dr John Clark, director of "Mobot" development at Hughes Aircraft. (Mobot is the generic name for Hughes mobile vehicles.) Pacing a vehicle through an intricate series of motions heavily taxes the communication channels between console and vehicle, he says. Signal density can be reduced if the vehicle performs routine functions without step-by-step direction.

Hughes is now working on a research vehicle, the Mark II, which is being built primarily to prove that complex operations can be effectively controlled by a remotely situated operator. Hughes is benefiting from the experience of building Mark I—a mobile vehicle now operating in the nuclear lab at Sandia Corp. (*PE*—Sep 28, '59, p 26.) Mark II electrical controls will replace its predecessor's hydraulic controls.

The Hughes Mobots are designed primarily for land use, particularly in nuclear facilities, but can be easily adapted to underwater applications. Dr Clark expects most future uses of robots to be underwater for mineral and petroleum surveys or for military applications. If some sort of underwater DEW line is built to protect the US from surprise submarine attack, these underwater vehicles will have to prepare sites and assemble and check out equipment.

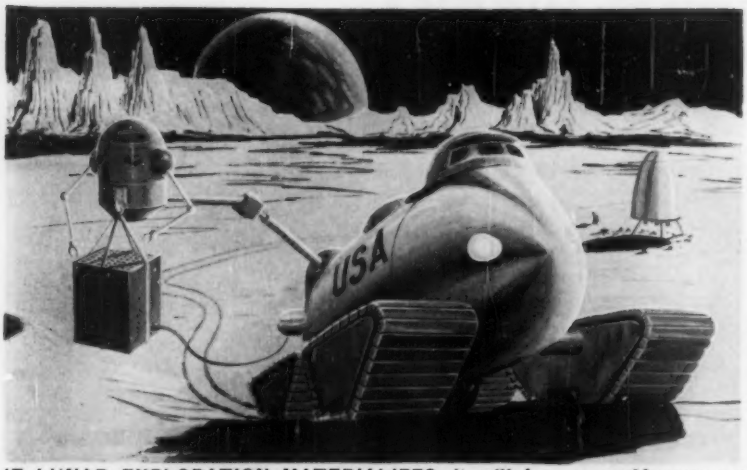
FOR UNDERWATER—RUM AND MERMAT

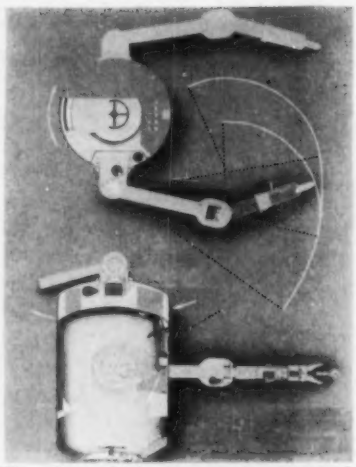
A number of vehicles especially designed for underwater work are now in the works. Scripps Institute of Oceanography is developing RUM (Remote Underwater Manipulator) for the Navy (*PE*—June 27, p 15). Essentially, it's a small tank with an articulated arm mounted at front and a large reel with control cable at rear. But final configuration is expected to be considerably different, according to Dr Victor Anderson, engineer in charge.

RUM can now operate only in shallow water because a few minor accessories, including lights, have not been adapted to a high pressure of deep water. Components that do not operate in vacuum are filled with oil to resist sea pressure.

General Mills has designed a specially articulated boom and adapted one of its six standard mechanical arms for RUM. High-torque hydraulic actuators provide rotation and articulation for the boom. And an electrically controlled hydraulic servo valve provides precision control. When extended 7 ft, the boom can lift 1000 lb; at 15 ft it lifts 100 lb.

RUM carries 5 mi of coaxial cable ($\frac{1}{2}$-in. outside dia), which is reeled out as the vehicle moves along the ocean floor. This cable carries drive





IF LUNAR EXPLORATION MATERIALIZES, it will be done by a vehicle that looks something like this, according to AMF. Capsule suspended from boom at side of vehicle could carry a man. His job would be to operate a control console for the mechanical arms that would do much of the work involved in setting up a base.

current and 48 signal channels. Current originates at 480 volts, and whatever voltage arrives is normally further reduced for use. Because the cable is slender, RUM cannot operate from a floating ship where the cable might be dragged along the ocean floor.

A troublesome design problem, according to Anderson, is traction. Tread pressure of the tracks on the ocean floor must be kept under 1 psi and in some areas under ½ psi. With higher pressures, ground squirts out from under the vehicle and it sinks.

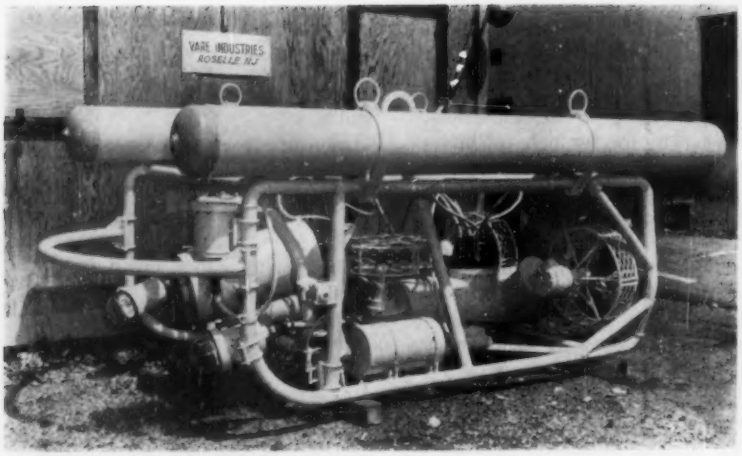
Traction is no great problem for the Mermat, an underwater vehicle developed by Vare Industries of Roselle, NJ. Mermat glides above the ocean floor, driven by three fans—two vertical and one horizontal. The vertical fans at port and starboard turn the craft right and left, the horizontal fan raises it to the surface. These fans are controlled from a console on board a surface ship.

This unit is expected to have a variety of applications. At present, it's being used by the military to retrieve test missiles. Oil companies are interested in it for geological surveys, and companies with underwater cables, such as AT&T, see it as a possible inspection device. Mermat can also be programed to perform a fixed routine, then turned loose as an underwater submarine-decoy.

Equipped with arms, Mermat can also work underwater. Unlike related underwater craft, the Mermat and its work-performing accessories are separate units. The vehicle delivers clamps, claws, or other instruments to the ocean floor, then returns to the surface with their control lines. Because of the vehicle's balance and

THIS MECHANICAL CLAMP, slightly adapted for underwater corrosiveness and pressure, will be the working arm of RUM, the Scripps underwater vehicle. Arm can swing and rotate at the shoulder joint, swing at the elbow, rotate at the wrist; its hand can grip an object with 280-lb pressure, and open 7½ in. wide. The arm has three steps in speed and power sequence.

HUGHES MARK II MOBOT HAS TWO ARMS, each capable of 10 different movements. Arms have three joints—shoulder, elbow and wrist, and each of these has two degrees of freedom. The hand extends 3½ in., rotates 360°, and opens 4 in. Pads on hands inflate to assure light touch with delicate objects. Two other arms support TV cameras that scan horizontally and vertically. The control cable, linking Mobot with console, carries 100 command channels.



A PIONEER AMONG UNMANNED CRAFT is Vare Industries' "Mermat"; it has already made underwater forays for exploration, study and work. The unit has closed-circuit TV, and three propellers to give directional control. Cylinders at top are buoyancy tanks. Also shown (at right) is its control console.

buoyancy given by two air tanks, relatively small units can ferry tools weighing up to 13 tons from ship to ocean floor.

Mermat's claws and clamps are relatively simple. At first Vare considered using an articulated arm with wrist, elbow and shoulder motion. But it was found that most of these movements could be provided by Mermat itself. Present claws provide finger motion only. Mermat then lifts and rotates the claw to provide shoulder and elbow motion.

The vehicle can dive to 1000 ft and move over an area 2000 ft dia. Since the control line is not fixed, Mermat is able to move freely. The company now is drafting designs for vehicles to operate at 20,000 to 40,000 ft, though at these depths, the control cable still poses some problems.

PLAYBACK FACTORY WORKER

In hazardous industrial environments, articulated arms are a potential substitute for human effort. General Mills expects industrial applications to become increasingly important.

An articulated arm operating on an assembly line has to be programed to repeat continuously a sequence of operations. General Mills has developed a technique for writing such a program and has tested it on a process for applying powdered enamel to cast iron plumbing fixtures—an operation which takes place in a dusty environment on castings at close to 1800 F. The program was written for an articulated arm designed with five rotary and swing motions to it.

In writing the program, an operator at a control console puts the manipulators through the appropriate sequences of motions. As the movements of the arms interplay, the signal from the console simultaneously drives a playback mechanism coupled with a recording head at five rotating drums—one for each of the movements. The drums are made of plastic-coated metal. As they rotate, the recording head cuts appropriate lines on the plastic. Thereafter, the drum can be electrically excited and the playback mechanism will automatically activate the articulated arms accordingly.

Development of nuclear craft is creating a need for associated mobile vehicles for ground maintenance. One such robot, the Beetle, is being developed by General Electric. It will be equipped with a General Mills articulated arm. And several pieces of ground equipment are in conceptional stage at American Machine & Foundry under contract with Convair. The AMF program is still in low gear pending demonstration that nuclear engines can produce sufficient thrust to warrant development of nuclear aircraft.

AMF is also under contract with the Air Force Special Weapons Center, Albuquerque, NM, to develop a complex of equipment for handling emergencies with missiles that may someday carry nuclear engines. In the event of missile failure, the Air Force needs remotely controlled vehicles to move in on a crash site to fight fires and remove waste to a disposal area. This equipment, as AMF presently envisions it, will include two units with booms holding attachments to operate power saws, crossbars, shears, clamps and other implements. The emergency vehicles will be controlled from a console by radio and TV.

ROBOT MOON-MEN

AMF also has its robot eye on the moon. Someday man may set up a base there, and AMF engineers reason that now is the time to begin considering what kind of equipment will be needed. The company has sent a design proposal to Detroit Arsenal. It outlines some of the preliminary studies needed to build a three-man capsule with articulated arms for working at a moon base.

The moon will offer some interesting design parameters, AMF engineers point out. Gravity is about $\frac{1}{6}$ that of earth, but strength of materials is the same. Thus, cantilever beams can be designed with much less material than their earthly counterparts. But in dynamic situations, the same force is required to accelerate a vehicle on the moon and on earth. Hence designs involving vibration or rotary motion must conform to the earth pattern.

ROBOT PROBLEMS

A frequently mentioned limitation of mobile vehicles is the absence of pressure feedback to aid the operator. To overcome this handicap, the Remote Control Engineering Labs of Argonne National Labs has developed

a mobile vehicle whose mechanical arms are equipped with force-reflection servo mechanisms. Once the robot is positioned in the work area, its operator manipulates a set of mechanical arms whose motions are duplicated by the robot arms, which reflect back a sense of feel. Though somewhat similar to the early master-slave manipulators, the Argonne differs in that communication between operator and robot is transmitted electrically through a cable, rather than by mechanical connection.

Raymond C. Goertz, director of the division, says that, to his knowledge, no others in the field are building force reflection into their systems. But his group believes that pressure feedback will lead to "better, faster and safer equipment" wherever a human is involved in the operation. His group is now designing an improved model that will have similar over-all characteristics, but will be more dependable and easier to maintain. This will have two fingers. A more advanced model will have multiple fingers, maybe with a sense of touch. The big problem, Goertz says, is designing suitable hydraulic servo mechanisms.

—Dora Merris, assistant editor

Defense Official Warns Industry: Cut Costs—or Else

NEW YORK—A high government official has blasted at defense-industry management for its high production costs. Speaking before the 42nd Annual American Ordnance Association Meeting here, Russell A. Crist, director of Production Policy in the Defense Dept, warned that unless production costs are brought under control, the US will have trouble finding enough money to maintain the weapons in a state of readiness.

Within the Defense Dept., he said, "there are rumblings loud enough to cause all of us to pause for a moment and ask whether or not the American free-enterprise system is properly geared to serve the national interest as well as itself. The rumblings to which I have reference are sometimes faint and muted—and sometimes quite strident."

Crist laid the dangerously high production costs to breakdown of certain traditional characteristics of US industry: competition, prospect of profit, and risk of loss. In buying defense equipment, he said, only a minor portion of purchases are made on basis of competitive bidding. And expensive items like tanks, submarines and aircraft can be produced by only a few.

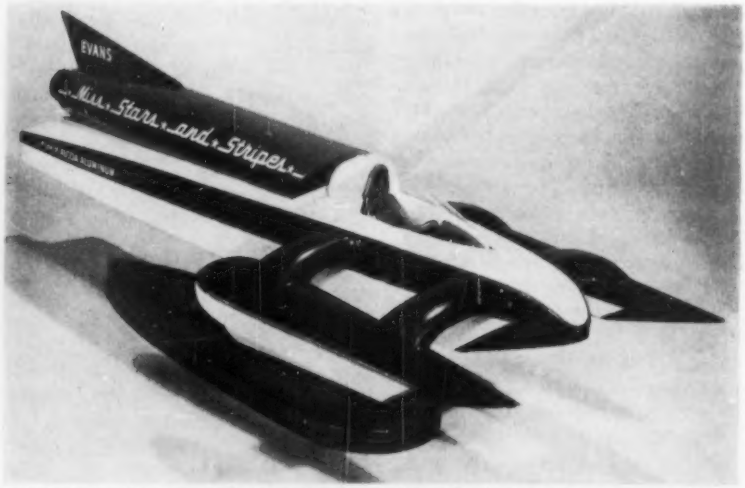
Somehow, Crist declared, "there is need for a new delineation of the government-industry relationship and for a revival of free enterprise in its purest form. In the absence of such reorientation, industry might well have good reason to look to its own future with misgivings. If it should develop that industry cannot effectively and economically serve the national interest, it is inevitable that new patterns for industrial production will evolve."

The defense-policy spokesman put three responsibilities on top-level management. First, business leaders should involve themselves more deeply in the process by which components and systems are described, produced and tested. Both industry and government must be sure that "contractual understandings define clearly, and in forthright, explicit technical and mathematical language, what the consumer expects and what the producer must deliver in terms of performance, particularly life expectancy."

Second, Crist suggested a penetrating look at production engineering and testing operations to ensure adequate provision for reviewing designs for adequacy and accuracy and ensure that test facilities are essential.

Third, he called for firm control over the entire process of design and redesign. "There is reason to suggest," he said, that repeated redesign and retest is exploited to serve the misguided interest of perpetuating bureaucracy and generating "made work" in industry. ■

Hydrofoil Craft Bids for World Speed Title



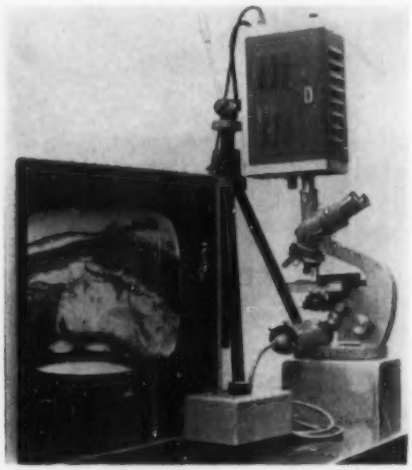
Fabricated with a special-alloy aluminum skin, this hydrofoil powerboat (scale model) will be used next spring for a US try at the world water-speed record. The craft, owned and designed by Robert Evans and Lester Staudacher of the Detroit area, weighs 58,000 lb and is powered by a J-35, A29A Allison turbojet rated at 8000 rpm and delivering 5600 lb of thrust. Vessel measures 31 ft 6 in. long and 12 ft wide; has a single-seat, open cockpit. It features outboard pontoon construction, similar to the design of Britain's Donald Campbell's Bluebird—still the only vehicle to have traveled more than 200 mph on water. Evans and Staudacher expect their craft to reach 260 mph.

Bi-company Research Seeks Thermoelectric Coolers

LONDON—Thermoelectric refrigeration systems are the basis for a joint commercial development program being undertaken by the General Electric Co Ltd and A B Electrolux of Sweden. Electrolux is at present demonstrating in Sweden a model that achieves a reduction of about 35 to 55 F. Intensive research in commercial application of the principle is being conducted in the US and the Soviet Union with reported reductions of 18 F below outside temperature.

The demonstration model is in-

TV Serves as Second Microscope



The "output" of a microscope is further enlarged, in this system demonstrated by Elgeet Optical Co, Rochester, NY, by putting it through a TV circuit. Result: many people can view specimens on a microscope slide simultaneously. The system, shown here, will provide magnification up to 3500 dia—1500 derived from the microscope, the remainder from the electronic equipment. It is expected to have wide application in electronic and metallurgical plants, providing rapid communication between the quality-test lab and the production line. It also has potential applications in schools and hospitals. The research model with 600-line TV resolution and trinocular microscope is expected to sell for less than $2200.

tended for campers, yachtsmen and car owners. Its only power source is a car battery from which it draws 25 to 30 watts. The refrigerator works on the principle that when dc is passed through a thermocouple, one junction is warmed and the other cooled. The development of semiconductors has greatly increased the efficiencies obtained and, as a result, has brought practical exploitation nearer fruition.

British GE, which makes electric compression-type refrigerators, has been doing research on commercial application of the principle for some years, and has demonstrated an experimental model to the Royal Society. Electrolux has extensive experience with the absorption-type refrigerator, and its new venture with GE is expected to accelerate development of a thermoelectric refrigerator at a competitive price. ■

France Names 7 New "Sages" of Science

PARIS—Five holdovers and seven new faces make up the new Science Research Consulting Committee that will advise the French government on science policy for the next two years.

The committee, known as the "Twelve Sages of Science," controls the supplementary research fund set up to strengthen French science in certain areas where France is lagging. Some $65 million has been allotted for this program through 1965.

The "Twelve Sages" will also play an important role in plotting development of science during the 4th plan which will start in 1962 and run for five years. For its 5-year plans, the French government works closely with industry in developing long-range plans to increase economic and social growth.

New faces include: an expert on radioisotopes, an authority on flight fuels, an economic analyst, a mathematics professor, a physicist, a humanitarian and an agronomist.

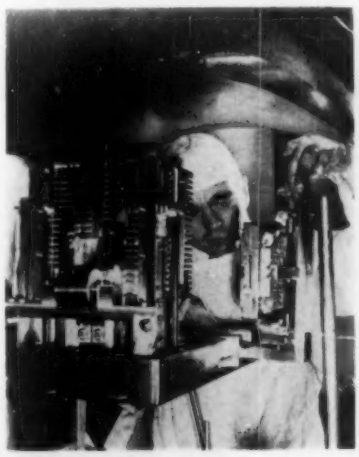
—Arthur Erikson, Paris News Bureau.

Cryogenic Memory Plane Automatically Produced

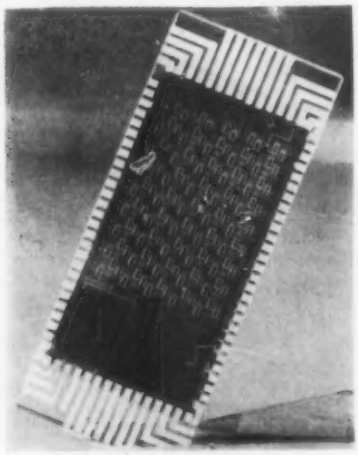
KINGSTON, NY—Successful fabrication of a cryogenic thin-film memory plane and the development of automatic control techniques capable of manifold duplication was announced here by IBM's Federal Systems Div Laboratory. The memory plane consists of 135 cryotron devices built up in 19 layers of material.

In the memory plane, three cryotrons form a memory cell which combines storage with an elementary logic operation. Because of this combination, it is expected that the concept may be used in an "associative memory," which simultaneously searches all memory compartments and thereby speeds access to stored information.

Key to the development is the special technique which permits accurate duplication of devices. By means of this technique, microscopically thin layers of metals and insulating materials are automatically deposited on a glass substrate. The equipment used for deposition allows each layer of a metal or insulator to be sequentially deposited through 17 microscopically adjusted masks, or perforated metal sheets. Once the masks are properly aligned, the process automatically produces duplicate super-conducting memory planes with similar electrical and mechanical characteristics. ■

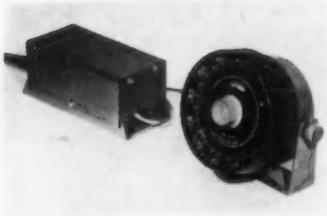


AUTOMATIC CONTROL TECHNIQUES permit duplication of the 135-cryotron superconducting memory plane. Masks that permit 17 layers to be sequentially deposited are held in a large metal cylinder that operates under high vacuum. Once aligned, masks produce automatically similar memory planes.

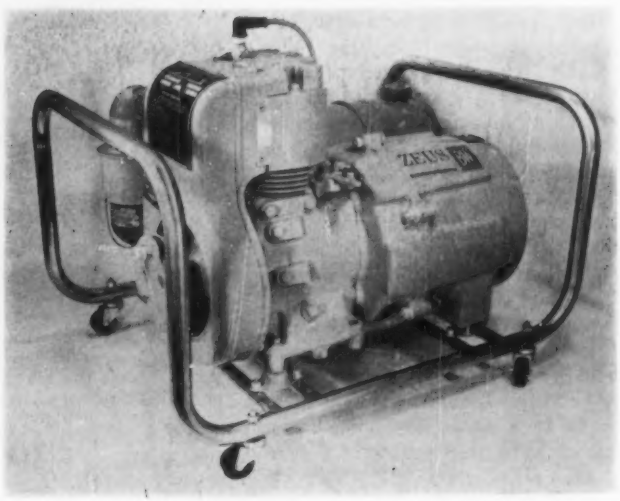


THIN-FILM MEMORY PLANE, about the size of a large postage stamp, stores 40 separate bits of information in 120 of its cryotrons. Of the remaining 15 cryotrons, 10 permit access to the stored bits of information; the other five are "in-line" units which switch bits of information from one memory plane to another.

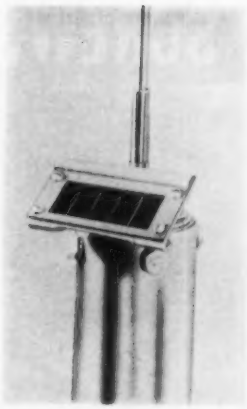
TRENDS IN APPEARANCE DESIGN



MARINE RADIO-TELEPHONE is housed in an aluminum case with weathertight molded-plastic panel, can be mounted vertically on bulkhead (left) or placed on shelf (below). Suitcase-type cover and clamps permit full access tb chassis without tools. Designed for operation under minimum-visibility conditions—and by touch alone. Various models are all transistor-equipped and provide for four to ten channels for two-way conversations. Yoke-mounted depth sounder, above, also for small boats, has most of its components and power supply in a receiver-transmitter unit that can be mounted away from control panel. Indicates depths to 120 ft. Made by Raytheon Co, Marine Products Operations, San Francisco, Calif.



PORTABLE ELECTRIC GENERATOR'S integrated look probably results from the fact that natural shapes of its generator, engine and flywheel cover have been allowed to constitute their own styling, without any any artificial decoration or superficial enclosures. Generator is actually a permanent-magnet alternator, with magnet connected directly to engine shaft. Brushes, slip rings, commutators and belts are eliminated. Rated at 3000 w, 115/230 v, 60 cps; single-phase, unit is powered by a rope-started, 1-cyl, 4-cycle, aircooled gasoline engine. Manufactured by Borg-Warner Corp, Pesco Products Div, Bedford, Ohio.



HIGHWAY EMERGENCY-CALL BOX has been redesigned from its former sheetmetal enclosure (*PE—June 20, '60 p 32*) to fiberglass-reinforced housing that drops down for servicing. Radio transmitter inside is battery-operated. Batteries are kept charged by five solar cells (center). Receiving and dispatching station's digital decoder (above, right) displays stranded motorist's location, direction and the type of service needed. Unfortunately, industrial designers Melvin Best Assoc, Pasadena, Calif, who designed transmitter's new housing for Hoffman Electronics Corp, weren't given a chance to clean up and simplify that decoder too.

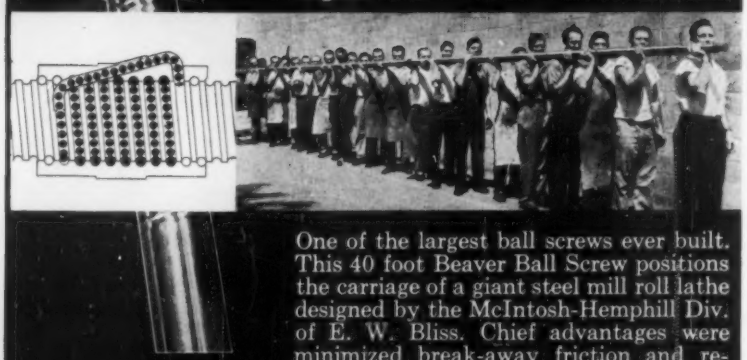
AIRLINER SEAT permits rows to be more closely spaced than present designs, yet is said to provide better knee room and greater "walk-in" room than present seating units—which contain nearly 500 parts compared to 70 in this new design. Entire seat, back and headrest unit can be inclined as much as 20° by pushing a button. Seat's shell consists of thermoplastic sandwich filled with foamed-in-place plastic; has detachable fabric or plastic-covered cushions. Forged leg units, which are mounted on 3-in.-dia tube, fit all standard tie-down tracks now used in airliners. The fact that the entire seat, back and headrest unit, inclines, rather than just the back as in present designs, might add to passenger safety in head-on impacts, but will probably make short-legged passengers even more uncomfortable than they already are in most seating. Made by Teco Inc, Burbank, Calif.

NOT THE SIZE OF THE JOB

but the demand for positioning accuracy determines the need for

BEAVER BALL SCREWS

Raytheon uses this Beaver Ball Screw in the "Hustler" search radar to actuate a delicate and extremely precise instrument control — everything else is classified, except that you can hold it between two fingers!



One of the largest ball screws ever built. This 40 foot Beaver Ball Screw positions the carriage of a giant steel mill roll lathe designed by the McIntosh-Hemphill Div. of E. W. Bliss. Chief advantages were minimized break-away friction and reduced power.

Our engineers will be glad to work with you in determining if ball screw actuation belongs in your product as opposed to hydraulics or pneumatics. Call on us.

Largest manufacturers of precision ball screws

Beaver Precision Products INC.

CLAWSON, MICH.

READER TO EDITOR

Correct Formula for ID Gage

To the Editor:

In your Oct 31 issue, p 9 ("What's Happening in Research") there is an error in the formula for the new ID Gage.

Simple geometry shows that $D = b + \frac{aW}{2L}$ $\frac{aW}{L}$.

—Brian Powell, *senior engr*
Litton Industries, Beverly Hills, Calif.

• Says the Navy: "The equation shown on the diagram should be $D = b + \frac{aW}{2L}$. Thanks for calling the mistake to our attention."—Ed.

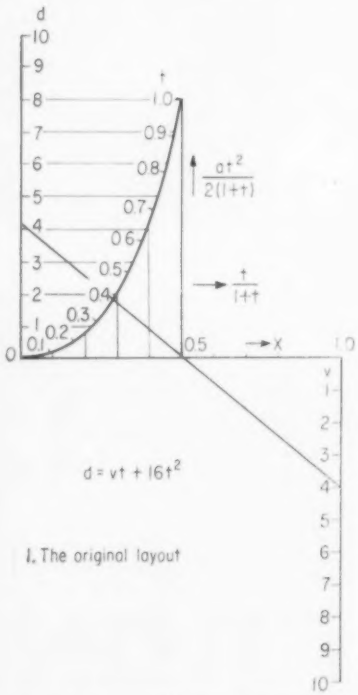
Wrong Projection

To the Editor:

Referring to your article entitled "Design Nomographs the Easier Way" on pages 66-74 of your Oct 16 '60 issue, I note an error in Fig 7. The nomograph is not constructed according to instructions by first scaling $t/(1 + t)$ along the slanted x-axis, and then scaling $at^2/2(1 + t)$ in a direction parallel to the d-axis. This results in the wrong answer to the example problem. The answer should be $d = 4(0.4) + 16(0.4)^2 = 4.16$, instead of 3.26.

In spite of this minor complaint, I find the article very useful and informative.

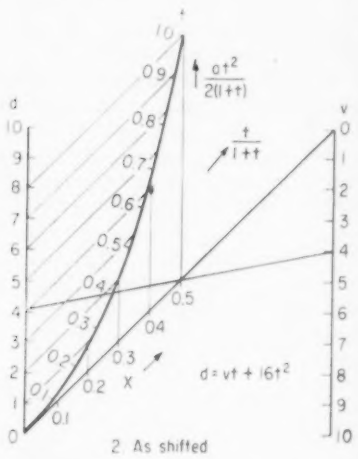
—Norman B North
Woodland Hills, Calif



1. The original layout

• Several other readers have questioned the author on the exact method for producing a nomograph with curved stems. Mr.

North is perfectly correct and the method is shown here—first as computed by the determinant, and second as shifted for a more convenient placement of stems. Note that each stem's graduations are projected parallel to the other coordinate.—Ed



Editors Note: A reader would like to dispose of the following bound volumes (text and advertising) of PRODUCT ENGINEERING: 1935 and 1943 through 1956. Anyone interested in obtaining these volumes, write: Reader to Editor, PRODUCT ENGINEERING, 330 W 42nd St, New York 36.

COMING EVENTS

DECEMBER

27 . . . . American Astronautical Society, Lunar Flight Symposium, Biltmore Hotel, NYC

26-31 . . . . American Association for the Advancement of Science, NYC

JANUARY

9-11 . . . . Institute of Radio Engineers jointly with AIEE, ASQC & EIA, 7th National Symposium on Reliability and Quality Control, Bellevue-Stratford Hotel, Philadelphia

9-13 . . . . Society of Automotive Engineers, International Congress & Exposition, Cobb Hall, Detroit

16-19 . . . . Instrument Society of America, Winter Conference & Exhibit, St. Louis

29-Feb. 3 . . . . American Institute of Electrical Engineers, Winter General Conference, NYC

For a current listing of addresses of societies and associations send 25¢ to PRODUCT ENGINEERING Reader Service Dept, 330 W 42nd St, NY 36. Ask for brochure R32.

for CORROSIVE SERVICE

wire cloth

In many metals including...
STAINLESS STEEL
MONEL • NICHROME
PHOSPHOR BRONZE
ALUMINUM
BRASS • COPPER

For many uses involving...
FILTER CLOTH • SIEVES
STRAINERS • SCREENS
BACKING CLOTH
WIRE GUARDS
BOLTING CLOTH
SPACE CLOTH
BASKETS

If you have a tough corrosion problem and need wire cloth or wire cloth parts, here's a source of supply that knows the answers. We are proud of the quality of our cloth...accurate mesh count, close tolerance wire diameter, precision weaving...plus the know-how necessary to specify the proper alloy for **your** service conditions.

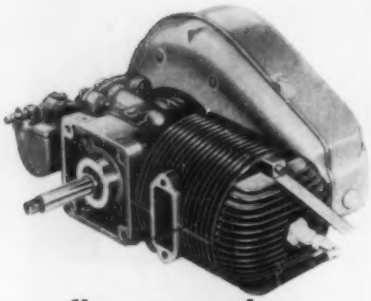
NEWARK for ACCURACY

Write or call us today if you have a problem calling for anti-corrosive wire cloth or wire cloth parts. Send for Bulletin F-C.

Newark Wire Cloth COMPANY

351 Verona Avenue • Newark 4, New Jersey

CIRCLE 23 ON READER SERVICE CARD



finest engines in the 2 to 5 h.p. class

Specify a power plant that matches the quality you've built into your portable equipment. West Bend's air-cooled, 2-cycle engines are carefully engineered and thoroughly tested to provide top performance and customer satisfaction. A wide range of factory tested optional equipment lets you tailor the engine to your exact needs.

WEST BEND Power Bee

Forged steel crankshaft

Carburized and hardened. Bearing and seal surfaces are precision ground and superfinished.

Anti-friction bearings

Crankshaft has ball bearing on drive end; roller bearing at magneto end. Rod has roller bearings at both ends.

SPECIFICATIONS

TYPE Horizontal or vertical mounting; air-cooled; 2-cycle, clockwise or counter-clockwise rotation (at drive end).

MODELS

SERIES 390 Displacement 3.9 cu. in. Rated horsepower 1.6 at 4000 rpm.

SERIES 580 Displacement 5.8 cu. in. Rated horsepower 4.0 at 4500 rpm.

SERIES 700 Displacement 7.0 cu. in. Rated horsepower 5.0 at 4500 rpm.

IGNITION Wico flywheel type magneto.

FUEL SYSTEM Float feed carburetor is standard; diaphragm type carburetor with integral fuel pump is optional.

VALVES Reed type; corrosion resistant.

FOR MORE INFORMATION

Write for colorful illustrated catalog on West Bend's complete line of Power Bee engines. Ask about the test engine program.

WEST BEND ALUMINUM CO.

Dept. 1441, Hartford, Wisconsin

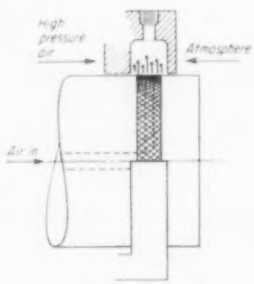
WHY DON'T THEY R&D..?

. . . a freezeproof water hose. When farmers, construction workers, firemen or army personnel lay temporary water lines in subfreezing weather, there is always the risk that the hose will freeze, particularly if the flow rate is low. To keep the hoses open and reduce the chance of bursting, an electrically heated jacket could be built into the hose wall. If the heater wire were of a material with resistance that increases with decreasing temperature, heat would be applied only to those areas where temperature dropped below a fixed level. The hose might be made this way: under a heat-insulating cover would be a concentric core of the material with negative temperature coefficient. With resistance inversely proportional to temperature, cold spots would have highest resistance and therefore generate the most heat. Warm spots will not generate additional heat (and thus draw no current) but will conduct current to the affected areas. A special power supply would keep the current low when the hose was in no danger of freezing. —I BREMA

. . . electronic scoring devices for sports events. Electrical scoring is now standard for fencing and dueling events; why not apply some of the same technology to baseball, football and rifle matches? A matrix of photocells or an electromechanical scanner could serve as an umpire in baseball, for example. Reflections from a suitably colored ball would indicate strikes and balls. Or how about a small portable radar, similar to the one the army uses to track mortar shells, to follow the path of a baseball. With data from a fly ball fed to a small computer, officials and radio announcers would know seconds before whether the ball would land fair, foul or over the fence.

Spectator interest in rifle and pistol competition could be improved if shots were recorded electronically. An image from the target would be focused on a grid of photocells which would be connected to a light-board to show where each shot hit. Total score for each target would be computed and displayed below the large electrical target. In football, an optical sighting device like the tracking telescopes used to follow missiles would establish the exact position of the ball on the field. With data from the X, Y and Z coordinates of the ball's position relative to the sight, it would show yards gained or lost, and yards to first-down, without need for present 10-yard marker chains. —R MARTI

. . . an "air curtain" shaft seal similar to those used to keep cold air out of doorless supermarkets and public buildings. Air would be pumped through the center of the shaft and out a grid or porous bronze section in the shaft. It would provide an effective seal between enclosed areas of different temperature, pressure or humidity and would not have to be lubricated or replaced because of wear. At high rpm, radial holes could be angled so that centrifugal force would automatically pump the air and contribute to the effectiveness of the seal. —G D PHEIL



Have you a problem, based on known scientific principles, which seems to have an answer somewhere within the limits of present technology? To inspire inventors along worthwhile paths, PRODUCT ENGINEERING invites you to trade such problems with fellow readers who have a fresh viewpoint or more time to experiment. We pay $10 for each one accepted.

PRODUCT ENGINEERING HORIZONS

December 26, 1960

It is more blessed to give

History is studded with the names of conquerors—Caesar, Attila, Alexander, Napoleon, Xerxes, Genghiz Khan, Tamerlane and the like. But other names—the names of those who conquered themselves—are in the hearts of the people. Joan of Arc, William Tell, Robin Hood, Tyl Eulenspiegel, St. Augustine, King Arthur, St. Valentine—each of these is a legend, a fabric of folk tales built upon the hopes and wishes of all of us.

Conquerors would, if they could, stamp out these legends, for among all the conquerors there is not one whom men want to remember, not one about whom they want to sing or spin rhymes, not one whose *birth* date they wish to celebrate.

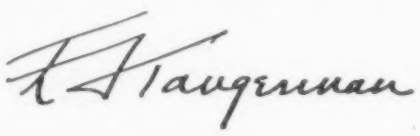
This season, however, is one particularly devoted to pleasant and peaceful memories, the story of the Babe in the manger, and the legends about Santa Claus. Our children recall for us an old, old story about a rich man named Nicholas who devoted his life to seeking out, and giving secretly to, the needy. To them he was a God-sent gift on the doorstep, a benevolent spirit who helped them when they were in desperate need. And because of them he became a saint.

It is only fitting that his memory should be cherished by innocent children, whether they call him St Nicholas, Father Christmas, Father Frost, Knecht Clobes, Bonhomme Noël, or the much more familiar Santa Claus. Kindly, benevolently, this spirit comes once a year to reward the worthy with gifts, to build in the hearts of little children the belief in the Golden Rule.

Perhaps herein lies the core of our grown-up weaknesses—that as we grow older we cease to believe, first in the physical Santa Claus, then in the idea of Santa Claus, and finally even in the spirit of Santa Claus. We substitute for the thought of *giving* the thought of *getting*. We base the placing and size of our gifts on the expected return.

This spirit of "get" dominates all of us too often and too long—in our personal lives, our business lives and our national lives. It seems only reasonable to expect that, just once each year, on the anniversary of Jesus' birthday morn, we may again have the faith of a little child. Can't we recapture, if only for that one fleeting day, the real and transcending belief that there is a spirit of Santa Claus, and do, each of us, our own little bit toward making that belief real to our fellow men?

It is little enough to hope for—and worthy of our greatest hopes.



actual size

NEW MINIATURE A.C. MOTOR

high output for commercial use

This a.c. synchronous motor costs you only about half as much as its miniature precision counterpart for military applications. In production quantities it is so economical that you can design it into good quality products that now use induction motors. And because you can put this **bigger** performance motor in **smaller** spaces, it gives you a head start in miniaturizing your design at the same time you improve product quality.

Vital statistics: This Type CMC motor has a starting torque of .7 oz. in. and a continuous duty torque of .7 oz. in. at synchronous speed. It is 1¼" in diameter by 2⅝" long, and weighs 6½ oz. The shaft is precision ground stainless steel, supported by ball bearings. The epoxy-sealed design provides good resistance to normal environmental conditions.

If you have hesitated to design with precision miniature motors in the past, now's your chance!

The Globe motor line includes both a.c. and d.c. models. Globe is pleased to work with you to provide the exact motor you need for your commercial, competitive product. Please write for Bulletin CMC. Globe Industries, Inc., 1784 Stanley Avenue, Dayton 4, Ohio. BAldwin 2-3741.

GLOBE INDUSTRIES, INC.

PRECISION MINIATURE A.C. & D.C. MOTORS. ACTUATORS, TIMERS, STEPPERS, BLOWERS & FANS MOTORIZED DEVICES

GLOBE

A PRODUCT ENGINEERING SPECIAL REPORT

DESIGNTOWN, USA

a study in depth of the design engineer

DR JAMES H SOLTOW Michigan State University

Endless articles appear in the popular press discussing the engineer and his characteristics, now that engineering is being popularly recognized. But what is the engineer really like? What does he think of himself? What do his boss, his wife, his associates think of him? Where is he going? Are his attitudes changing? To answer these questions, PRODUCT ENGINEERING asked an experienced business historian to make a detailed study. He spent the summer of 1960 interviewing engineers and others in a city carefully selected by our editors as "average" according to national statistics in terms of its size, engineers per thousand of population, types of industry, companies, and other factors. His report, on succeeding pages, is a fascinating analysis. He has held up a well-polished mirror to all of us. The subjects:

I. . . **Selecting an Engineering Career**
II. . . **Education of an Engineer**
III. . . **The Engineer at Work**
IV. . . **Opportunities for Advancement in Engineering**
V. . . **The Engineer in the Community**
VI. . . **Professional Status of Engineers**

ILLUSTRATED BY BILL STEIN

COPYRIGHT 1960 BY THE McGRAW-HILL PUBLISHING CO., INC.

DR JAMES H SOLTOW

To implement study of the design engineer at work and at home, Product Engineering offered a business fellowship this past summer through the Foundation for Economic Education. From the applicants we selected Jim Soltow. Here are some pertinent facts about the man we chose:

Dr Soltow teaches in the History Dept at Michigan State. He has previously taught at the University of Pennsylvania, Hunter College, Russell Sage College, and was in 1958-59 a business history fellow at the Graduate School of Business Administration, Harvard University. He's had two earlier fellowships, had his bachelor's degree from Dickinson College in 1948, has published studies like these: "The Business Use of Business History," "The Small City Industrialist, 1900-1950," "Small City Industrialists in the Age of Organization," "The Role of Williamsburg in the Virginia Economy, 1750-1775," "Scottish Traders in Virginia." He was described to us as "able, intelligent, dedicated, quiet, tactful, pleasant and agreeable." These he is, and a canny student and observer of people as well. In the Special Report that follows he has characterized the engineer so well he makes us squirm.

I . . . selecting

Why are engineers engineers? Good at math and science in high school? Parental inspiration? Aptitude tests? Or does the choice just "come naturally"? Here are some answers.

A paradox shows up immediately. Despite the emphasis that engineering places upon logical selection among alternatives, most of the engineers interviewed admitted that their own choice of a career was not made in this way. An exception was the man who took an occupational aptitude test when he was of high-school age and followed its pointer in the direction of an engineering career. (Even in his case, the test showed that he was as well suited for accounting as for engineering.)

Most engineers, though, reported ease and proficiency in mathematics and science courses in high school. Model-building and shopwork held more than average interest for them. One man described himself as a "real whiz" in shop courses in school. Several pointed to an interest in drawing at an early age. Generally, interviewees stressed their desire and ability to create and build things to explain why they eventually chose a career which involved the practical application of science.

In selecting a career, many prospective engineers were following in the footsteps of their fathers. As one individual pointed out, "It was always presumed

DESIGNTOWN . . . a typical industrial city

For this survey, we selected as nearly a typical city as possible, in terms of size and diversity of industry, engineers per thousand of population, and like factors. The city is not known for some particular industry or product, is centered in an industrial and market region, has high population density and manufacturing volume. Educational institutions are good, educational and cultural attainment levels high. Supporting services and utilities are adequate, transportation is good, civic and recreational facilities superior, government is progressive, but taxes are high. There are some housing shortages, traffic problems, questions about school curricula—in plain English, the city is as typical as we could find.

It has only six plants employing over 2000 people—none much over 10,000—11 between 500 and 2000. Population is in the 200,000 class, so there are over 70 elementary schools and almost 25 high schools, with about 1000 teachers.

an engineering career

that I would become an engineer." Not always did sons of engineers have a very clear view of engineering. When required to sign up for his major field in college, one man selected electrical engineering because he thought that his father was an electrical engineer, only to change his courses when he learned that his father was a mechanical engineer.

Other prospective engineers became acquainted with the field of their future careers as a result of experiences during World War II. For example, one man grew up on a ranch in Kansas believing that an engineer was the driver of a train. As a result of tests administered when he entered the service, he was sent to school to learn radar, which formed the basis for his interest in electronic engineering.

Regardless of how they happened to embark upon engineering, probably most engineers would agree with the individual who stated that he was only following "the path of least resistance" in pursuing a career based upon his interest in things scientific and technical.

Even those who viewed engineering as a "good field" in terms of future economic opportunities did not usually determine early the particular field of engineering which they wished to pursue. For example, one individual started in civil and switched to electrical when he became better acquainted with the different areas of interest. Another stated that he chose between chemical and mechanical engineering on the basis of "a flip of the coin."

Prospective engineers attempted, when selecting a career, to determine in at least an intuitive manner the extent of their own talents—aptitude in science and mathematics and a bent toward tinkering with mechanical things—then to find a field where these talents might be most profitably utilized. **That so many men fell into their chosen fields almost by chance would seem to indicate a failure in dissemination of knowledge about opportunities in engineering and its various fields to qualified individuals.** Only in recent years, apparently, has any serious attempt been made to meet this need.

Most interviewees think that their choice of engineering was the best one for them. There are, in fact, only two exceptions. One is the man who went directly from engineering graduation into the service and felt he was "rusty" when he got out. He went into personnel work, but his engineering training is apparently helping in recruiting and hiring engineers because he "speaks their language." The other is the executive vice-president of the local manufacturers' association, who left the profession after he got his degree in the 20's. He went into newspaper work because he couldn't find the kind of job he wanted. Here, too, there is a question—depression job conditions or personal preference?

continued, next page

Much has to be learned on the job

II . . . education of

Should the embryo engineer specialize? How current are curricula? Can the employer be expected to help train? Just how valuable are humanities? How long should the curriculum be?

All levels of engineers interviewed—from top management to newcomers—agreed on importance of the engineering education that stresses broad fundamentals rather than narrow specialization. As one man pointed out, engineering "would have to be split into many categories to enable a person to step directly from college into a job without further training by the employer." Another explained that today's technology is "too complicated for meaningful specialization in college; with a good grounding in fundamentals, an able individual can learn to do almost anything." Or this from a manager: "There are so many avenues of development for the engineer that much has to be learned on the job." Furthermore, few students can know early enough the specialized area in which they will want to pursue a career.

Broadly speaking, the large company tends to hire talented and broadly trained individuals and to work them into specific jobs after they've had an opportunity to try several during their first year with the company. The small organization cannot afford this; its new engineers are expected to start carrying their weight as soon as employed. This may make it necessary to "chop up the work," as one manager put it, to make the new man or men able to contribute. Basically, the big organization can usually fit a job to a good man; the smaller one must find a man to fit the job.

One manager maintained that it is the responsibility of the employer to decide the specific application of the fundamentals learned in school. An engineer who was graduated from a well-known technical school in the early 1950s recalled that recruiters from industry generally disregarded students' fields of specialization and advised prospective employes: "We will train you." In a large corporation, policy is not to look for new engineering graduates with qualifications for specific jobs; rather, it is to hire talented individuals who can be trained for positions in their areas of general interest.

While there was some criticism of insufficient amounts of physics and mathematics in engineering curricula, many engineers—particularly those in small and medium-size companies—urged that emphasis be placed on practical aspects. **A manager, formerly a university professor, decried the recent tendency "to go overboard on the scientific side into exotic fields which are not needed in industry." "Too much theory, not enough application," commented a young engineer, "new people don't know how corporations work." One manager pointed out the need to tie principles more closely to practical application, but that this should not go as far as teaching shop-type courses.** What engineers need most from their formal educational experience, and sometimes lack, is greater ability to define and approach engineering problems. That academic institutions have been moving in this direction, toward practical application, was noted by a young man who saw the shift in his own alma mater (University of Minnesota) between 1955, when he secured his BS, and 1958, when he returned to do graduate work.

Opinion was divided on the role of nontechnical subjects in the education of the engineer, reflecting in turn differences among academic institutions and the experience of individuals. **Some pointed to lack of ability to communicate as the greatest shortcoming of college curricula. One man stated that he knew of engineers who worked out creative ideas**

the engineer

in the early years of their careers, only to give up in futility when they found themselves unable to express the ideas to others. However, an engineering manager, formerly on the faculty of an eastern university (NYU), commented that he personally knew of few "horrible examples" of illiterate engineers. "The situation has become greatly exaggerated in the public mind." **While differing on the extent of the problem, all agreed on the importance of effective presentation, oral and written. "Ideas have to be sold to be effective."**

Some engineers regretted the small amount of liberal arts in their formal education. One individual pointed out that there was time for only six hours of electives in humanities out of the total university requirement of 152 hours for graduation (Syracuse Univ). Yet the professor-turned-manager believed, on the basis of his own experience in the academic world, that **the public has a misconception of the supposedly narrow scope of the education of engineers.** He maintained that prospective engineers had wide opportunities to pursue nontechnical interests in college, and that those who ducked the opportunities were generally the poorer engineering students.

What is the role of the humanities and social sciences in the education of the engineer? The manager of a medium-size company producing power tools held that training in the liberal arts was valuable to the engineer as a person, but not particularly useful from an engineering point of view. Another engineer, who reported broad interests in music and literature, classified these subjects in the "nice-to-know" area which might, under pressure of time, have to give way to the "need-to-know" subjects of engineering.

Another aspect of educational background was stressed by several graduates of engineering schools of Ivy League universities. They pointed to the general climate and strong liberal-arts tradition of these institutions, where engineering students are in daily contact with students of other disciplines. As one man put it, "This was a broadening experience even if I had not taken any liberal-arts courses."

Some engineers and managers would put liberal-arts courses into the "need-to-know" category for engineers. As the manager of a medium-size company producing consumer durable goods pointed out, "These things are used by people, for which a knowledge of people is necessary." A manager in a large electronics company maintained that liberal-arts courses might be useful in helping engineers to understand why people bought certain consumer goods.

Because of the vast amount of learning that has to be packed into the education of the engineer, **there was widespread sentiment in favor of extending the period of engineering education to five years.** Yet, in a discussion of this subject among a group of engineers in a large corporation, several men noted the widely varying amounts of work required at different institutions. This led to the suggestion that schools might be able to squeeze more into the four-year course of study. In a similar vein, a manager of a

Curricula fail to teach communication

smaller durable-goods company maintained that many colleges are too lax in requiring students to exert individual effort.

To some perceptive engineers, **the need to stimulate creativity was a problem of much more importance than that of the number and content of courses. If individuals are not stimulated during college years to make searching inquiry about doing new things in new ways, they are not likely ever to do so.** This has a very practical aspect for the potential engineer as well as for industry. **What about further training?** Engineers generally accept the term "commencement" in its literal meaning. Four years of study marked by a degree represented only a preparatory program for the understanding of their particular phases of engineering.

The large corporation usually has placed its recruits fresh from the campus in a rotating program which includes a year of assignments in three or four of its installations. In this way, the individual is encouraged to seek the type of work for which he believes he is most suited. Smaller companies, unable to support an extensive "breaking-in" period for new personnel, have sought to get men "on the first bounce" after they have been "seasoned" in a large corporation.

To enable its engineers to keep abreast of new developments in fields of rapidly changing technology, a large electrical-equipment company offers technical courses on a regular basis. These courses are generally given on company time by employes of the corporation who are experts in their particular fields. One engineer described the courses which he took as "real eye-openers" to what was going on in his field. Another reported that the company courses were "much more rugged" than graduate courses which he had taken in a leading engineering school (Georgia Tech).

To fill in gaps in other facets of the education of the engineer, the corporation has also developed a series of courses in effective presentation (written and oral), professional management, and the like.

Large and small companies alike have encouraged their employes to take courses in the evening division of a local university. One large corporation, for example, pays 75% of tuition charges when the individual completes a course and the remaining 25% when he secures a degree. Another large company pays 75% of total costs at the time of enrollment, the remaining 25% if the student receives a grade of B or better. A smaller company pays 50% of costs of courses taken for a degree, the entire cost only if the course is work-related. In some companies stipulating that the course be work-related, the term is defined very loosely. For example, on engineering manager reported that his employer paid for a course in world history which, it was held, made him more valuable to the company by broadening his outlook.

The company paid for a course in history

Although most companies grant leaves of absence to engineers who want to devote full time to advanced-degree work, in practice the economic factor of foregoing salary limits the possibilities for individuals to earn in this way a master's or doctor's degree in a relatively short period of time. Most who pursue graduate work do so in the evening division of the local university. This also poses problems, such as availability of course offerings at convenient times. Even if course work proceeds smoothly, major difficulties develop at the thesis stage: Can the part-time student base his thesis on work-related material? If the company, for competitive reasons, cannot permit publication of work carried on in its plant, the individual usually lacks time to work on an entirely different project off the job.

From the point of view of industry, the advanced degree itself carries little or no cash value. One man who started to work in 1946 reported that he would have received $5 more per week in starting salary if he had completed all of the requirements for the master's degree. The company attitude holds that work for an advanced degree indicates that the individual is preparing himself to do a better job. Therefore, most engineers in one large corporation believe that company courses, which earn no credit for degrees but which are noted in the record, will benefit them to a greater extent than work at academic institutions. **A graduate degree as such, except for certain research fields, is regarded as of**

value only when changing jobs, as an objective criterion of achievement in the field.

Formal course work is not the only method by which engineers advance their knowledge of the field. **Most men reported a heavy load of reading in their specialties.** As one engineer commented, the only limit to the amount of reading to be done is the time available. Thus, amounts of time spent in work-related reading varied considerably among individuals. **Some devoted as much as 14 hours per week, on an average, part at home, part in the office.**

Company policies about reading during working hours differ. In larger companies, there are apparently no formal restrictions. Individuals are free to exercise their own judgment. A manager of a smaller company, however, stated that he believed that engineers in his department should use their own time for reading which was not directly connected with company projects on which they were currently working. He encourages his men to take magazines home, or to read them during lunch hour or coffee breaks.

The tremendous volume of publications poses a serious problem of selection. The engineer, in looking for new ideas and new hardware, concentrates on a few magazines or journals central to his interests, then tries to "thumb through" as many more as he can. A designer of portable tools reported this schedule: thorough reading of two design magazines, both of which he receives by subscription at home. He skims rapidly at work, during lunch hours, three others. He pays considerable attention to the advertisements as well as to editorial content and regularly uses the reader service cards.

An advanced-development engineer made an interesting comparison of technical-society journals and trade publications. The former, he believed, were not usually useful. If an article was in his own specialized field, he learned nothing new because "the meat was usually cut out"; if not in his field, he could not understand it. On the other hand, from articles in trade publications, written in more general terms, he could determine whether study of a particular new development in a related area was worth pursuing.

Most engineers, like the one reported above, watch the advertisements closely. Here they look for as much information as possible about a product or service, to determine whether it is worthwhile to call or write the manufacturer or distributor for further data. These are the kinds of questions which he tries to answer when reading an advertisement: Does the advertisement give complete specifications? Does it adequately describe performance and the like?

In summary, the engineer and his manager see as of most value a broad education in the fundamentals of engineering, oriented to the practical side, even though as a student he could not always see the relevancy of the broad fundamentals. The engineer regards four years of school as only a commencement of his education, which he is continuously advancing in company courses, academic work, or reading to keep abreast of new developments. As one individual with 10 years of experience put it, **he has spent as much time studying since he started to work as he did in college.**

Employers want magazines read OFF the job

III . . . the engineer

Are distinctions between disciplines blurring? Can the engineer communicate? What does a project engineer really do?—and the engineering manager?

Research Joins Development. An important result of the rapidly changing technology of recent decades has been to blur the distinctions between the scientist and the engineer, as well as those among the various disciplines of engineering—mechanical, chemical, electrical. In research and development in modern industry, the chemical engineer and the physical chemist, for example, may work side by side. Men with training in "pure science" may move into the applied area, and men with engineering education may drift into the laboratory where the major concern lies in developments far removed from current product lines. As the research director at one company pointed out, **the academic distinctions made some 80 years ago have no meaning in today's technology.**

At this company, research and development are organized as separate departments. The research department, as might be inferred, is geared to basic research, while development carries ideas to prototypes which, in turn, can be made by manufacturing into salable units. To illustrate the blurring of distinctions in terms of formal background of personnel working in R & D, the senior project scientist in the research department was trained as an electrical engineer; the senior project engineer in development was trained as a physicist. As the latter individual commented, **"anyone who designs and develops consumer goods is an engineer regardless of the type of his formal training."** Although the emphasis of the work of research and of development may be different, "there is no dividing line," in hard and fast terms.

Generally, a combination of long-term and short-term considerations governs selection of individual projects to be undertaken. Sometimes the pressure of competition stimulates R & D to look more closely into a particular area. Occasionally, "bugs" appear in products, which are sent back to research for further study. Although product engineers may build up a body of empirical knowledge in investigating such defects, the work of research is directed to a basic understanding of why such failure occurred.

The major task of R & D, though, lies in the investigation of new possibilities in products, processes, and materials—**things which will be feasible perhaps five to ten years in the future.** Research at one company, for example, examines carefully into product lines: compressors, generators, motors. What are the underlying technical phenomena about each of these? Do we need to know anything more in these areas? Because theory has rather well explored these phenomena, the next step is to seek alternative ways. In this manner, research is directed to investigation of the thermoelectric approach. When principles are better known, development can apply them to specific products.

Before long-range projects can be undertaken, initial investigation must determine the probable magnitude of the effort. **Are probable results of ultimate interest to the company? Will the company be able to finance the research to completion? These are critical areas of management decision.** At least one R & D man emphasized that top managers must have technical competence to know the direction of a possible new product in areas of industry where the tides of innovation flow strongly.

The individual member of this research department is assigned an area within which to work—such as a problem in heat transfer—but he exercises his own discretion as to methods of attack. The senior physicist, for example, may be personally working on two different projects and have responsibilities for supervising the efforts of several scientists and engineers in five or six other projects.

Senior researchers are encouraged to devote 10% of their time to unassigned work which may prove to be of value ultimately to the company. This has

at work

frequently been the source of new ideas and fresh approaches, according to the director. If the individual's unassigned work shows definite promise, it is incorporated into the budget as an assigned project.

Communication between R & D and Manufacturing is a critical problem. Advanced-development engineers sometimes regard engineers in Manufacturing as the "meat-heads" who put out day-to-day fires, which is not really engineering. Similarly, the manufacturing engineers may look upon the "scientist-type" in R & D as an overly theoretical, "pie-in-the-sky" kind of person. Even where a feeling of mutual respect exists, a development engineer commented, communication may be difficult. Engineers and managers in the factory, tied up with daily problems of production, cannot always see the need to disrupt established procedures just to try some new "fool thing" being pushed by R & D. Thus, an idea for a new product may lie dormant for months or even years before its acceptance, often dictated finally by marketing considerations.

In some cases, a new product has been moved from R & D into Manufacturing by transferring a whole group of people with the product. Management may regard a new item as attractive enough to move to market, but cannot find the skills in operating divisions. Usually, the individuals return to R & D after production procedures have been established.

The Project Engineer. "Engineering runs the line," commented a project engineer in one plant's semiconductor products department. In both military equipment and consumer goods, the project engineer carries responsibilities and participates in decisions from the inception of the idea until the item is worn out in the field.

To carry out these responsibilities, the project engineer receives from his manager a considerable amount of freedom. **"Results count" is the rule of the game accepted by both the engineer and his manager.** Indeed, the engineer views his task as one of "finding ways to produce certain end results." To do this, he is encouraged to use his talents to the fullest, with a minimum of supervision. Management does not question the engineer's going out for a haircut during working hours. On the other hand, the engineer does not expect overtime pay if he has to spend a few evenings or Sunday afternoons to complete a job on time. **One interviewee maintained that he solves most of the real problems he encounters in the hour or so after most of the rest of the staff goes home and he is no longer interrupted by the telephone.**

Although he may work on a project in a highly specialized area for as long as three or four years, he meets new challenges often enough to keep his job from becoming one of repetitive routine. The talented individual, according to one project engineer with 20 years of experience, is not "pegged in a hole and left there." However, "anyone who wants to find a hole can dig it." **Most engineers and managers in Designtown companies believe that the issue of using trained engineers in routine work has been exaggerated;** that steps are being taken to hire more technicians to handle such tasks; that a certain amount of routine is inevitable; and that the individual very

Manufacturing engineers are firemen, R & D thinks

often determines the amount of routine in his job. As an engineer at one plant pointed out, some individuals with engineering degrees are happy with semiclerical work and mold the job in this way; when such a person leaves, the job becomes upgraded by management to require a level of experience not really needed; the new occupant, if he possesses initiative, then has to reshape the job to meet his own goals and capabilities.

Although the project engineer is not classified as a manager, he assumes supervisory responsibilities, sometimes for as many as 30 people. He makes assignments and is responsible for the work of the engineering personnel working on his project. In making the annual appraisal of engineers' performance, the unit manager often relies heavily upon the project engineer's estimate of the contribution of the men in his group. But leadership exercised by the project engineer comes from the individual rather than the title. **As one young man put it, the major task is to find ways "to get people to do the job without needing the formal authority of a manager."**

In lines such as military equipment or broadcasting apparatus, where products are specially designed to individual customers' requirements, the engineer is closely acquainted with the customer. He must know what the customer requires so that he can put it into the product. In the initial stages, the engineer feels out the customer along with the salesman, conceives the idea, then gets the salesman to sell it.

In consumer-goods lines, too, the engineer plays an important role in marketing decisions. At one durable-goods plant, for example, engineers attend sales meetings where they can present to marketing men data on such matters as costs and feasibility of product modifications suggested by salesmen. "It is rare, if ever, for top management to bypass Engineering in making important decisions about products," reported an engineering manager.

The project engineer's responsibility does not end with the completion of blueprints. He works closely with Production, helping the factory to interpret plans.

Likewise, the project engineer must remain in close contact with his counterpart in related programs. An engineer working on airborne missile controls, for example, must make sure that his product will be compatible with the ground-control system being developed at another installation.

An important area of responsibility of the engineer lies in relations with subcontractors and vendors. In one company's heavy-military-equipment department, some 50% of the work is subcontracted. The general rule is to go outside for work which is not in electronics, such as heavy machining, for example. Although Finance draws up the contract with the successful bidders, the engineer must approve the final version of the contract if it has any engineering content. The project engineer or one of the men in his group periodically visits the subcontractor's plant to check on progress, quality control, production problems, and the like.

Engineers tell the salesman about costs

The project engineer also deals directly with vendors. Not only does he interview salesmen regularly, but he also reads magazines (advertisements as well as articles) for information on new equipment, components, or services available. If he sees an advertisement which seems to indicate that an item will meet his requirements, he calls the local representative. Although Purchasing makes the actual selection of a supplier, based on price, ability to deliver, etc., the engineer makes suggestions to Purchasing about potential vendors. **Also, in practice the engineer may have quite a bit of control over vendor selection by his power to set the specifications, thereby limiting the number of suppliers** able to perform the work. Furthermore, he may specify a certain source of supply if he can define the special need for that manufacturer's product (uniqueness, superiority in reliability and quality, etc.).

With the completion of the manufacturing process, the project engineer acts as consultant to the men in the field, supervising installation, testing, ironing out "bugs," and perhaps advising on repairs after use in the field.

The project engineer sees himself as the hub of the wheel around which the work of the company revolves. As one man put it, "the engineer is the one man in the company who must believe that he is the key to the company. Everything centers about the product and the man who conceives it and controls it." This is definitely "psychic income" to the engineer. Even though he may be confronted daily with the evidence that a salesman is paid more and receives more salary advances than he does, the project engineer usually carries the job through from idea to production, so he has a right to his belief that he is the "key."

The Engineering Administrator. The engineering manager must possess a high level of technical competence to supervise the work of engineers. At the

same time, he must be adept at dealing with people.

Because the manager is rated on the results of the work of the group, **his first concern is to spot qualified people for his unit, then to assign the right job to the right man.**

Some of the manager's tasks are technical in nature: scheduling work loads, seeing that jobs are completed on time, evaluating the ability of individuals who work for him, ordering equipment.

But getting the most out of men who report to him poses many problems of human relations for the administrator. **Some engineers respond readily to recognition of their achievements; others require "a good kick in the shins every now and then" to perform at their best.** Some men are most productive when they work by themselves; others do best when they have technical assistance to do the leg-work. It is the job of the supervisor to recognize these varying types of people, to assign them to tasks most suited to their talents and temperaments, and to make them aware that all are treated on an equal basis. Furthermore, the administrator must keep his men satisfied with the rate of advancement possible in the current situation.

Most managers believe that they must know the men who work for them as individuals. If a man is not producing according to his capabilities, the supervisor attempts to determine the cause of the problem —a task which sometimes requires considerable ingenuity. The managers act occasionally as family consultants in discussing home problems, other times as educational advisors in suggesting certain courses which might improve a man's potential.

How does management view the role of the "oddball," the man who in attempting to do new things in new ways may sometimes step on toes, who may sometimes be not very understanding in his relations with fellow workers? Although administrators in personnel sometimes raised their eyebrows at the mention of the word, managers of engineering units were generally cognizant of the need to **balance the creative contributions of such people against the potential disruption of administrative routine.** As one manager put it, "I'm getting paid for the headaches and I just try not to let it get my goat" if the oddball happens to be difficult to get along with. Another manager pointed out "you have to recognize their abilities and contributions" rather than their personality in assessing their value to the unit.

An administrator with almost 20 years of experience noted the existence of a "high correlation between creativity and oddball behavior," because creativity is by definition different and "it usually takes guts to do something different." **He cited a case of a highly creative individual who had to do his own drafting because he could not get along with any of the draftsmen. Another oddball was so impatient to get things done that he once almost burned his eyes out while welding without helmet and goggles. According to this manager, the important point is to give the oddball a creative kind of job to keep him happy.** Besides being useful in tackling and solving the toughest problems, the oddball helps to keep the more conforming engineers in the unit from becoming too self-satisfied by "shaking things up now and then." Thus, the oddball contributes indirectly as well as directly to innovation.

Even the "normal" engineer, defined by a personnel administrator as **a person who behaves in the expected way about 75% of the time,** sometimes finds difficulty in understanding the basis for decisions by top management. Why was that project, which seemed to have so much promise, dropped or shelved? Thus, a major task of the engineering administrator is to act as liaison between engineers and nonengineering management. The manager must know company policy and be able to interpret it to his men. At the same time, he sees himself in a position to explain to top management some of the goals and methods of thinking of engineers.

In a sense, the types of talents required of engineering managers are contradictory. On the one hand, the engineer is inclined by training and temperament to solve all problems on a formal basis. He sees only black and white. He finds the correct answer to a problem. On the other hand, the administrator must supervise each individual in a different way to get effective performance from each. He deals largely in areas of human emotion where the **many shades of gray predominate. The answers to management problems are not usually clear ones of right or wrong.** Although the potential manager may acquire some of the necessary skills of administration through professional management courses offered by his company or a local university, the transition to management usually requires something of a new orientation in outlook.

continued, next page

Administrators must be psychologists

IV . . . opportunities for advancement in engineering

Can an engineer really win out in engineering, or must he shift to management? Does the usual engineer want to be a manager? What factors influence advancement? What about transfers, teaching?

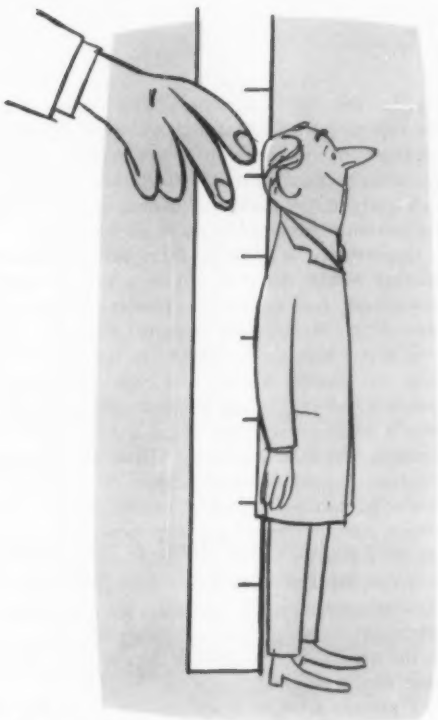
Traditionally, the opportunities to advance up the economic ladder have existed in movement into the ranks of management. With the greater demands of technology, business leaders have become concerned about the potential loss of creative technical talent in this way. In line with the recent trend in American industry, many companies in Designtown have now developed—or are planning to develop—policies whereby unusually creative individuals may advance in salary and prestige on the basis of their technical contributions. According to one big company's policy, there is no theoretical limit to the advancement of the highly creative individual along the technical line. Management of another plant is currently setting up new job classifications which provide parallel responsibilities and salary levels in the technical and administrative areas.

In actual practice, the creation of equal opportunities for technically oriented individuals cannot be achieved overnight. **There is universal agreement that the progress of the technical consultant in industry is slower, that the individual contributor attains less prestige than his counterpart in management. Some commented, though, that the situation has been changing within the last two or three years in companies conscious of the problem,** and pointed to instances in which individual contributors receive higher salaries than the managers to whom they report.

Yet, in spite of growing opportunities along the technical line, more engineers continue to focus their future ambitions on management. "You still have a lot more prestige if you have people working for you," commented one engineer with goals in administration. Another pointed out that the "accepted definition of success in engineering is still management." According to this individual, experience necessary for advancement can be gained more rapidly by supervising because "the experience of those who work for you rubs off on you." In this way, the engineering administrator can rise rapidly.

Engineers who have elected to seek advancement on the basis of their technical skills are far from dissatisfied with their situation in industry, especially in view of the growing awareness by top management of their accomplishments. One man pointed out that "the company does quite well by its individual contributors" even though engineers may advance higher and faster as managers. Furthermore, these men derive a great deal of "psychic income" from their work and view themselves as the "real engineers" in the corporation. Though some possess administrative talents, according to their managers, they insist that they do not want "to waste their time with paperwork and pencil pushing." **"After spending six years studying the harnessing of natural forces for the good of mankind, spending my time to sign time-cards holds no interest," emphatically stated a high-salaried technical consultant who had had a brief fling at management. "I would be miserable in the management area," commented an engineer in advanced development; "my interest in social standing (which the status of a manager brings) is zero."**

The technical consultant regards his own role as one of making the real decisions which affect the future of the company and of the nation, that this is more than worth the sacrifices of money and prestige in comparison with an administrative role. The individual contributor values highly the independence which he possesses in working on prob-



Spotting and rewarding talent is important

lems, usually those of his own selection within a broad frame of reference. **One technical consultant described his job as one of "keeping my boss's eyes open on problems areas."** He is free to select specific problems to tackle; only once in three or four years has he been told to undertake a specific task. The individual contributor may feel freer than the manager to be a bit nonconforming in certain details—such as wearing a sport shirt and no necktie to work. As an individualist—one who likes to work by himself—the technical consultant takes great satisfaction in being rated on the basis of his own personal contribution, rather than on the work of other people.

Although they are often of opposite temperaments and goals, there is generally a high degree of mutual respect between managers and technical consultants. Managers have learned to rely heavily on the highly skilled and creative individual contributor to get the work of his unit done. Similarly, technical consultants recognize that there is a kind of creativity in the nontechnical area which the able administrator possesses.

Factors in Advancement. Of major concern to both the engineer and management is the method which the corporation uses to spot talented individuals and to provide them with appropriate rewards. Various devices have been utilized in different organizations, even in the same company at different times.

In large corporations, the work of the engineer receives an annual evaluation by the manager of the unit. In this evaluation, the major test is the value of the individual's contribution to the corporation. **"Results count," as one engineer put it, and this is often one of the hardest lessons for young men fresh from the campus to learn about corporate life.** Although some element of subjectivity inevitably enters the evaluation, conscious effort is made to rule out so far as possible the intangibles—initiative, drive, and the like—which are difficult or impossible to measure. Most important are the answers to such questions as these: **Does he complete his work on schedule? What degree of creativity has he demonstrated, for example, in finding ways to reduce costs and/or to improve products?** Discounted in the manager's evaluation are long hours of unproductive "busy work."

After the manager has completed the annual evaluation, he goes over it with each individual, who then has the opportunity to point out what he thinks to be any errors of judgment.

Most engineers believe that they and their contributions are generally evaluated quite fairly by their managers. They know that the manager is rated by his superior on the basis of the contribution of his unit—therefore on the work of the engineers in his unit. The theory underlying annual evaluation by the manager—that each engineer is "a tool with which the administrator works to get his job done"—tends to minimize the effect of such things as favoritism or "personality clashes." The judgment of the administrator of a unit whose contribution is rated as only average, but who rates most of his men as outstanding, is suspect by higher echelons of management. Similarly, a manager of an outstanding unit who fails consistently to recognize the contributions of his talented engineers would not long continue to secure effective performance from his men.

If the annual evaluation determines *who* will go up, the situation in the specific department has much to do with *how fast* the talented engineer will rise. General policy is to promote from the ranks of the department into the lower echelons of management rather than to pull somebody in from the outside. Thus, great importance attaches to be-

ing on the "ground floor." The opportunity for the engineer with talent and ambition to become a manager is considerably better in an expanding department than in lines which are more or less static, where it is necessary to wait for somebody to die or retire before anybody is advanced.

Opportunity to transfer from one department to another within the company is a key to rapid advancement for talented engineers. Managers of expanding departments seeking engineers usually look first within the company. In the large corporation, this process has become highly formalized. A manager looking for an engineer sends to the company's central personnel office a list of the qualifications which he is seeking. These are matched by machine against the data about all company engineers, maintained on IBM cards, showing at first glance perhaps two dozen men potentially qualified for the position. Reading of detailed resumes further narrows the field. After securing permission from the engineers' current managers, the hiring manager interviews three or four individuals whom he regards as the most able. An offer is then made to the engineer finally selected.

Transfers in most cases are not made arbitrarily by the company. **Engineers may decline to make a change in jobs for many reasons:** the work on which they are currently engaged cannot be effectively transferred to another man; or, children may be at critical stages in education. **But, one manager noted, persistent refusal of transfers indicates that the individual lacks the flexibility believed to be characteristic of the most talented engineers.**

In some cases, engineers who feel that their advancement is blocked by a static situation in their departments may initiate the transfer process. Approved company policy is to ask permission first from one's supervisor to "look around." But many men make informal inquiries first "to make sure that they can better themselves before they leap."

Few engineers fear they'll be lost

All in all, the possibilities for advancement look good to engineers. Few feel that they will become "lost" in the large organization. As one young engineer commented, opportunities are excellent for those "who are willing to work for advancement and who do not limit themselves" through refusal to move or to assume new kinds of work.

Most engineers agree that the increasingly complex technology of the Space Age has sharply improved opportunities for themselves relative to those for men with comparable talents and length of formal education. They feel generally that their lifetime earnings, for example, will exceed those of the college graduate in business administration. Some, though, look on sales as providing a more rapid rate of advancement than engineering—particularly for the sales engineer who combines engineering with a business administration background. A few engineers have at least dim goals of establishing their own businesses at some time in the future. A young engineer who hopes to go eventually into consulting or small manufacturing believes that he could in this way have "a freer hand to do things as they should be done"; that this would "make things more complete."

The "ivory tower" of the academic world has a strong pull for some engineers, particularly those in research and development. And indications are that the exceptionally talented engineer who goes into the university will suffer little or no economic deprivation. One research director pointed out that it is becoming increasingly difficult for industry to compete in the market for top engineering talent, that university salaries plus consulting fees compare favorably with salaries in industry.

But several engineers who moved from the university to industry pointed to the importance of factors other than total annual income in comparing the two. Some mentioned the irregularity and uncertainty of consulting work and fees. This was cited by a manager who took a cut in annual income when he left his position at a large university (NYU). Geographical location of the academic institution in relation to prospective industrial clients is important in determining the over-all economic desirability of a specific university position.

Perhaps the leading consideration for men in advanced development is the availability of research facilities in large business organizations. A young PhD, who described himself as "more sympathetic to the university approach than to industry," declined a recent offer to return to his alma mater at an excellent salary primarily because he was reluctant to give up his research for a year or so until a properly equipped laboratory could be organized on the campus.

V...the engineer in the community

He's a doer, not a joiner

When and where is the engineer a "joiner"? Does he use his engineering—consciously or unconsciously—in civic or other activities? What's he like at home? Is he honestly a "do-it-yourselfer"?

The engineer in Designtown is not likely to be a member of civic or fraternal organizations just for the sake of being a "joiner." Only a few take an active part in local politics, and these are generally managers.

Yet the engineer does assume responsibilities in projects where he can apply his specialized knowledge or where specific civic goals can be reached through his action. **Sometimes individual engineers have run for school boards, for example, to be in a position to push the role of science and mathematics in school curricula.** Others have helped to organize the construction and operation of community playgrounds. One engineer has come out of retirement to work with a metropolitan development commission which is concerned with such matters as water supply, parking and urban renewal. Engineers also participate in the activities of a local business-climate council, particularly on task forces examining education, transportation and the like.

In recent years, engineers' associations have taken over some important community responsibilities. One company's engineers' association, of which most engineers are members, has a civic affairs committee which performs such tasks as repairing the record players at a center for blind people. Members also maintain the portable respirators at a local hospital.

Another facet of engineers' participation in the life of the community is evidenced by the work of an over-all local technical societies council. This was formed to coordinate the activities of local chapters of more than 30 engineering and scientific societies.

continued, next page

One of the council's major tasks has been to stimulate interest in technical subjects in highschool. To do this, it has organized a speakers' bureau, through which engineers in local industry are assigned to speak to classes about work and opportunities in their own fields. In cooperation with the manufacturers' association, the council has sponsored science fairs at which teen-agers show exhibits which they have built. The council also invited top science students from the local schools to its symposium featuring nationally known speakers.

Perhaps the engineer's view of his community responsibilities is best expressed, as one engineer put it, by "doing things rather than joining things." "There are too few hours in the day of the engineer to be a 'joiner'."

The Engineer at Home. The engineer regards himself as "the homebody type, more stable, if less exciting to the women." Outside of work, many of his interests center in home or family activities. While engineers in management, manufacturing, and sales are gregarious, like to associate with other people in the community, and talk about politics and other matters in social gatherings, the design engineer more often prefers the company of his fellows with whom he can talk shop and theory.

However, every engineer has, or hopes to have if he is a young man, his own workshop in the basement. With his power saw, electric drill, lathe, and other woodworking equipment, he likes to build or refinish furniture and make house improvements such as enclosing the cellar steps. Indeed, the engineer is seldom satisfied with his house the way it stands. Two engineers who were interviewed built their own homes from scratch. Some engineers have more elaborate metalworking machinery at home, with which they develop new ideas. One man, for example, invented a new type of boat lift in his home shop. As a handy man, the engineer usually does his own household-appliance repair jobs, and a few perform major work on their automobiles.

To some engineers, "do-it-yourself" work around the house is a source of considerable personal satisfaction. As one man put it, "You can't see concrete results in your professional work usually for a month or two; that is the basic reason why I like to tinker around the house." To other engineers, though, this type of work loses its charm "because you do-it-yourself all day around the company." Some engineers may feel ashamed to call in outside repair men because they regard themselves as "expert" in things technical, but others point out that they regularly rely on experts in their work and that this habit carries over to the home in decisions whether to try to repair an appliance.

There's satisfaction in doing home repairs

At any rate, engineers are likely to view with a critical eye the work done by repairmen and perhaps to feel that they could do it better. Even those who regard things like appliance repair as a chore rather than a pleasure pointed out that they disliked to waste their experience. Because he possesses the know-how, the engineer believes that he can save the money and, perhaps, do a better job than the outside repair man. According to one man, "the engineer attacks a job with the faith that he can see it through. He is accustomed at work to tackling problems of a physical nature about which he has to learn as he goes."

Engineers in Designtown pursue a wide diversity of other interests. One man is a Civil War buff who spent a recent vacation touring battlefields in Virginia. Several in their gardening specialize in unusual flowers and plants. Another builds electronic systems which play lights by music. Other hobbies and interests cited include: singing, playing the violin, dancing, painting, photography, attending concerts, model building.

Generally, those who are interested in sports prefer participant to spectator sports. The range of activities includes: boating, fishing, swimming, bowling, gymnastics, hiking, camping, golf, badminton, skiing. As one man put it, engineers are inclined to be "doers rather than watchers." (The interests of engineers, though, parallel those of other middle-class groups, as reflected by increased sales of boats and outboard motors and camping equipment, and the decline in some regions of attendance at professional and semi-pro sports events.)

Although many engineers reported that they had time to read little besides a local newspaper and perhaps such fare as *Time*, *Reader's Digest*, and the *Saturday Evening Post*, a number cited wide interests in literature. One was currently engaged in learning

all that he could about hypnotism. Another reads as many books as he can about the history of World War II. Others mentioned interests in books about current world affairs, archaeology, exploration, historical fiction of the American Revolution, and science in fields other than their own specialties.

Many engineers count church as one of their important interests, holding positions on vestries, Sunday School staffs, boards of trustees, and the like. The wife of one engineer described her husband's work in his church as "a vitally important part of his life."

Are engineers as "narrow-minded" and "uncultured" as some outside the profession have charged? This is a point on which engineers displayed some sensitivity. Perhaps the best defense of the engineer was given by a young PhD, a man of unusually wide interests himself. (He shared the views of many in the academic world about some of the elements of popular culture in America. For example, he characterized a popular picture magazine as "for those who can't read"; and a popular news weekly as "for those who can't think.") His main point was that the range of interests of the engineer should be judged in relation to that of other groups in the population. **On this basis, "the general public is much more narrow than the engineer; people in other areas should be subject to criticism for knowing as little as they do about science and math." He maintained that engineers were not necessarily more learned than other people, but that they were "at least as well trained" outside their vocational area.** (He cited the case of his brother-in-law, a physician, whose major off-the-job occupation is watching television.)

The Engineer as a Consumer. Because of his technical knowledge, the engineer likes to regard himself as an unusually intelligent purchaser of consumer durable goods. Trained to be critical on the job, he attempts to carry this over to his personal buying. One man referred to the joke about the engineer who surprised everyone when, on receiving a gift, said "Thank you" before he picked it up and examined it.

The engineer often prides himself on being "a tough customer" in his dealings with salesmen. One engineer who designed his own house related how he "gave the builder a hard time by watching every nail that went in." Another pointed out that he had difficulty in getting a contractor to build his house, because most contractors in the community did not want to deal with engineers. **A real-estate salesman in Designtown confirmed that engineers are the most difficult people to whom to sell a house.**

As a purchaser of consumer goods, the engineer certainly has some advantages over the ordinary consumer. Because he knows materials, he may be able to determine, for example, the probable durability of a strip of plastic on a refrigerator door. In areas related to his work and training, he can assess reliability of mechanical operation.

But engineering is a broad field with many specialties. As one man admitted, the engineer is ofen "a tough customer," not because he knows more than most people about the product, but because he is suspicious without grounds. He often assumes that he knows more about the construction and operation of an automobile, an appliance, or a house than he really does. Granted that he is "trained to be critical," which extends to his buying habits, he may lack the competence to be critical in areas outside of his specialty.

Probably most engineers turn out to be pretty "typical consumers." **Like many other people, they accept the validity of reports on branded products in a popular consumer magazine. They often rely on "inside tips" from friends in plants which produce consumer goods:** "I know some of the fellows over in Television Receivers where they tear down all of the competitors' products, and they tell me XYZ is the best." But when the engineer buys the product with the chrome strips and gadgets instead of the one with the best engineering underneath, it is the wife's choice which predominates. As one engineer described his recent purchase of a house, there was "no logic at all" involved; he would be much better off economically to continue to rent, but his wife was determined to own a home.

continued, next page

"Most difficult to sell a house"

VI . . . professional status

"Engineer" is a loose definition

What does the engineer really think of the agitation for professional recognition? What about licensing? When should "engineer" be used? Does the engineer really have a professional attitude?

Engineering as a Profession. Engineers in Designtown pointed to the generally accepted criteria of professionalism and its application to engineering:

1. The engineer who regards himself as a professional emphasizes the importance of learning—not just four or five years of formal education but a continual effort to improve himself and the state of the art. As one man put it, "engineering is learning-centered."

2. A key characteristic of the professional is his recognition of his responsibility to society and to the individuals whom he serves. He must realize that each decision may have far-reaching effects—as basic for the engineer designing missiles for national defense as for the physician dealing with human life.

3. The exercise of these characteristics depends largely upon the attitude of the individuals who pursue the occupation. The professional regards his job as more than an 8-hour-per-day path to a salary check. According to one man, "the engineer must be interested in doing the job right, aside from the financial reimbursement which he receives."

4. Closely connected with this is the assumption that the limit to the individual's contribution, hence rewards, is set primarily by his abilities and use of his talents. The engineer as a professional has considerable discretion as to how he applies his unique knowledge to particular problems. To put this another way, by using independent judgment within a broad framework, he can make or break his job. The engineer who regards himself as a professional is a strong believer in individualism.

His Problems As a Professional. Some engineers expressed a considerable degree of criticism of the recent literature and discussion about professionalism and professional status in engineering. A manager stated bluntly, **"I am personally tired of the subject."** An engineer at a durable-goods plant believed that it was largely a matter of "some people trying to puff themselves up." But a perceptive project engineer at a large plant pointed to the confusion existing in discussions of professionalism: "It is hard to put your finger on just what it is trying to accomplish." Some have emphasized greater recognition of engineers by the public, others, improved quality of service by engineers to society; still others, economic status. In view of these various approaches to professional problems in engineering, it is not surprising that the engineers in Designtown cited a number of difficulties which might be encountered in efforts to raise their professional status.

1. There is widespread agreement that, as one engineer put it, "the term 'engineer' should be distinguished beyond its present use." Because of the loose definition of "engineer," public confusion exists about what engineering is. Many engineers pointed out that the title "engineer" should be reserved for men with four or more years of formal education. **Greater effort should be made to distinguish in the public mind the engineer from the driver of a locomotive, or from the technician or draftsman.**

However, it is difficult for any group to reserve the use of a specific title to those with certain qualifications and training. Witness the term "doctor," once reserved for men with a broad humanistic education until it became associated in the public mind with medical, dental, or veterinary training. Similarly, "engineer," a title conferring status, will be appropriated by other groups as they attempt to upgrade their own position in society. An extreme example in popular humor is the effort of the garbage collector, or the

# of engineers

plumber, as the case may be, to become more important by calling himself a "sanitary engineer."

2. Closely connected with the loose use of the term "engineer," many felt, is the lack of effective standards for determining who should practice engineering. This in turn reflected the basic difference in economic status and legal position between the physician or the lawyer as a free professional and the engineer as a salaried employe. There is no real equivalent in engineering to the laws which prevent individuals from practicing law or medicine unless they meet certain definite requirements.

Is the professional engineer's license the answer? Although some engineers maintained, as did one with his state license, that "anyone in engineering should have a license," there were frequent suggestions as to necessary changes which should be made in licensing or registration procedures. One man pointed out that licensing should be on a national instead of state basis, to eliminate the widely varying standards which currently exist among the states. Licensing should also take into consideration the many special areas of engineering, instead of the current emphasis on civil engineering.

A major obstacle would remain: getting industry, which now bestows the title "engineer" upon individuals, to accept a more rigid set of requirements. At least, management currently pays little more than lip service to the license. A large corporation, for example, officially encourages its engineers to take the licensing examination, and provides classroom space for refresher courses, but most men agreed that there was little practical reward given beyond a free dinner for successful applicants.

Even among vigorous advocates of licensing there is recognition that passing an examination does not necessarily "change a man's morals," that "a licensed engineer can still bring disrepute or mediocrity to his profession." But the hope expressed is that by licensing "we can pin down faith in engineering in areas where the public has to accept the judgment of the engineer." To put this another way, licensing cannot raise the ceiling for greater opportunities for engineers as professionals, but it can provide a firm floor under the profession by weeding out the borderline cases.

Some engineers suggested that the technical societies might play a role in setting standards, similar to that of the medical and legal groups. But they admitted that in the past, at least, the economics of society operation dictated an emphasis on quantitative rather than qualitative considerations in recruiting.

The real engineer eats, drinks and sleeps it

Another way to provide higher minimum standards, according to some, is to fix standards in engineering education, particularly in marginal institutions. An important facet of the problem is the practice of some corporations to employ on an equal basis graduates of accredited and unaccredited engineering schools. If the voluntary accrediting agencies are unable to enforce accepted standards in education, perhaps compulsory government regulations may be necessary. According to a young European engineer, the engineering schools in his homeland of Denmark are required to meet standards imposed by the government. Partly as a result of this, their graduates are recognized as professionals when they embark upon their careers.

3. An important obstacle to improving the status of engineering in the public mind is the lack of direct contact between the engineer and the ultimate consumer of his services. In contrast to the situation of the doctor or the lawyer, to whom the public takes its problems directly, **the consumer of engineering services rarely knows what the engineer does.** Because of this lack of knowledge, "each person feels that he has a certain amount of skill in the area of engineering." As one engineer commented, "You can't be a sidewalk superintendent in law or medicine, but everybody is willing to express his own opinion on engineering." In contrast to the emergency during which most people deal with a physician or lawyer, where price factors are minimized, "people stop to evaluate the worth of engineering service."

continued, next page

As something of a paradox to this "sidewalk superintendency" imposed upon engineering is the frustration which the engineer sometimes feels when market considerations, particularly in consumer goods, require him to "cut corners." Although the engineer is often blamed for "under-engineering," he points to the ignorance of the consumer who overlooks quality considerations. As one manager pointed out, the consumer's ownership costs are almost doubled when the life of an appliance is cut in half to achieve a 10% reduction in price to meet the market. Similarly, the engineer is baffled when consumers fail to accept the product into which he has designed not only reliability and durability but also important safety features as in the case of a power lawnmower produced by one company. (This is a field in which accidents have been so common that the manufacturers' association reported that "only 8% were caused by faulty design." The percentage should of course be almost zero, but users don't seem to mind.)

4. Perhaps the most important point about professionalism stressed by engineers in Designtown was the importance of the way in which the individual engineer conducts himself, aside from formal standards, education, and the like. As one man active in a large company's engineers' association commented, "The only way to get engineering recognized as a profession is for all individuals to act as professionals." **"The real professional engineer," according to a manager, "is one who comes close to eating, drinking, and sleeping engineering."** He is the one who is "primarily interested in putting engineering to the service of the world." Furthermore, this is an attitude which "must come early" to the individual and "must be accepted like religion." It has to be instilled at school and reinforced in the early years of the engineer's career.

The problem, according to one manager, is that "too many engineers don't think of engineering as a profession, and this is what keeps engineering from becoming a profession." The nonprofessional type of individual "uses engineering" primarily for his benefit, as "a meal ticket"; he "does not give the job any part of himself."

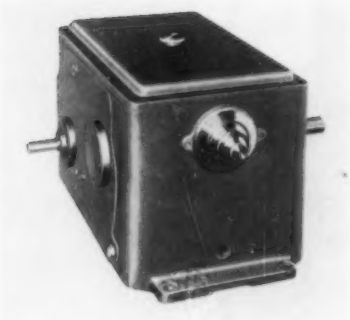
A technical consultant in missile work at one plant sees two categories of people employed in engineering work: the *non-dedicated*, who put in 40 hours per week carrying out the formal requirements of their jobs, and the *dedicated*, who are engineers 24 hours per day, 52 weeks per year, who are "the people on top, responsible for the breakthroughs in knowledge." He regards the latter as comprising perhaps 10% of the number of men who call themselves engineers. The 90%, the non-dedicated, are necessary to relieve the dedicated from much of the routine, the "dog-work," at least for the time being until they are replaced by machines which can perform such work.

This conclusion that only 10% of engineers are truly professional was confirmed by the observations of a personnel administrator at one plant, a nontechnical man who has had extensive contacts with engineers. "Nine out of ten don't have a professional attitude. They want prestige, but they don't want obligations and responsibilities."

In view of the emphasis that engineers placed upon individual conduct as the most important key to professionalism, **the approach through groupism to raise the status of engineering would seem to have little chance for success in Designtown.** Although the engineers' association at one company concerns itself with some economic matters, such as salary surveys to match those made by management, its leaders carefully point out that "we stear clear of anything resembling union activities." (The generally conservative outlook of the Designtown community may also have something to do with the avoidance of unionism. An independent businessman observed that from his own experience engineers are not inclined necessarily to be either "conservative" or "liberal," that much depends on the environment. At the University of Minnesota, most of his fellow engineering students had been conservative in their outlook; at Brooklyn Polytechnic, where he received his master's degree in 1952, the prevailing temper of engineers was liberal.)

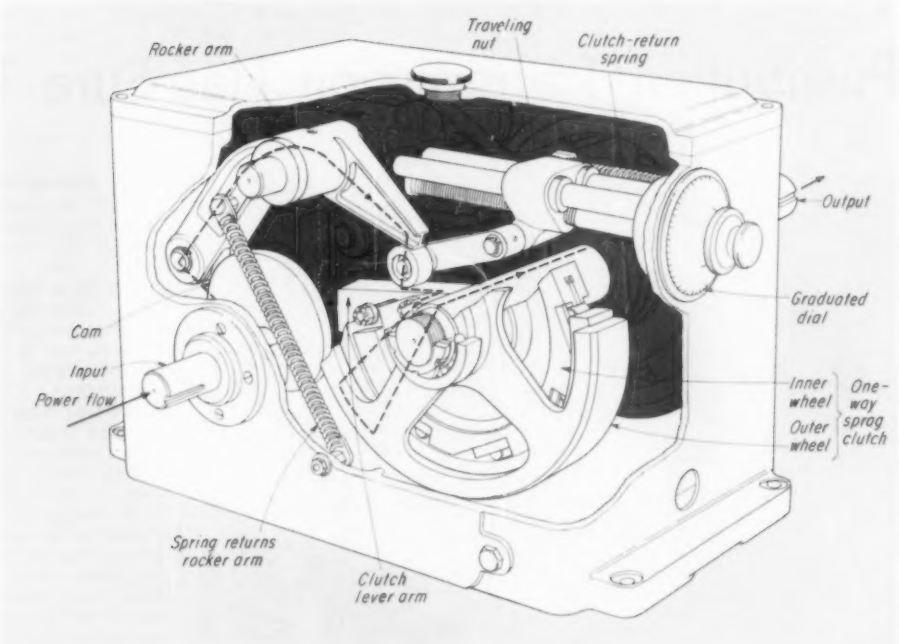
THE INTERVIEWEES

Men interviewed (about 100) in this study include personnel men, design, project and supervisory engineers, quality-control men, R & D and advance-projects engineers, supervisors and managers, technical consultants. Practically all engineers, they range in age from new graduates to men over 55, with only two or three having degrees from the same college. Several have doctorates, a number have master's degrees. They represent, rather than "typical" engineers, those who are most able in their respective organizations. In addition, several wives of engineers were interviewed. So were the local power-company vice-president, city and area development executives, presidents of three small companies (all engineers), the executive vice-president of the local manufacturers' association, and the executive secretary of the Chamber of Commerce. These latter interviews were of course to give perspective on the engineers' opinions of themselves.



Special-shape Cams Reduce Speed Smoothly

They oscillate two parallel power trains, but blend these motions perfectly to produce constant speed output. Just a twist of a dial sets any ratio from 9:1 up.



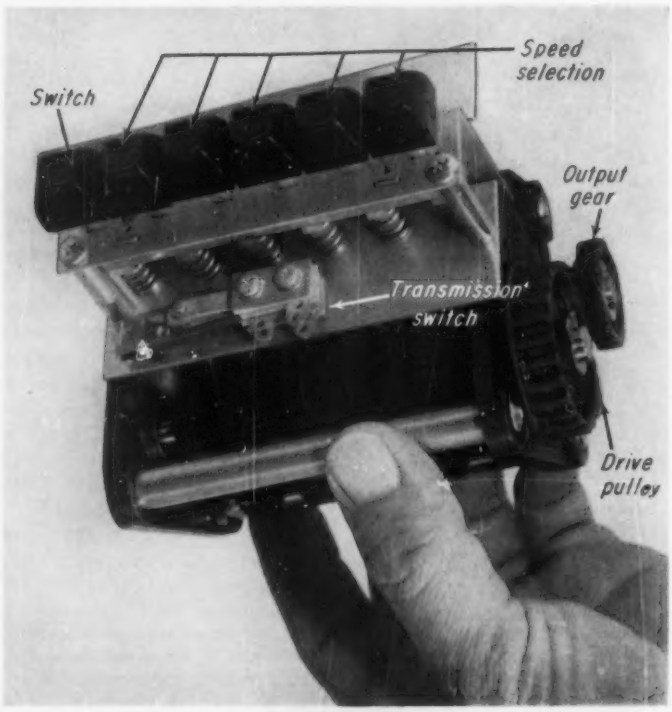
SPEED-REDUCER converts single rotary input into oscillations in two parallel power trains and recombines these oscillations into a single rotary output of the desired speed. Input shaft carries one cam for each power train. Cams are shaped to move rocker arms up and down in proper phase relationship to make the oscillations overlap and produce a smooth output rotation. Each rocker arm transmits movement through a roller to a clutch lever arm. This arm drives the inner wheel of a one-way sprag clutch. Sprags between the inner and outer wheels grip during forward motion of inner wheel and release during its return travel. Outer wheels on each of the two clutches turn the output shaft, maintaining the preset output speed without fluctuation.

Length of output rotation for each stroke of the rocker arm—and hence the output speed—depends on position of the roller between the rocker arm and clutch lever arm. Reduction ratio is infinity (output is stationary) when the roller is held directly under the rocker-arm pivot. Reduction ratio is 9:1 and output speed is maximum when roller is placed under end of the rocker arm as shown in drawing. An infinite variety of intermediate ratios can be set by positioning the roller between these extremes. Dial positions moving nut which locates both rollers simultaneously while unit is stopped or while it is operating.

PS . . . Max output torque at any speed is 2520 lb-in. Highest permissible input speed is 450 rpm; highest possible output speed is 50 rpm. Power limit for the unit is 2 hp, which is reached at 50 rpm and 2520 lb-in. output torque. Units are available with clockwise or counterclockwise drive. With its self-contained oil supply, speed-reducer weighs 385 lb. CONtorq is made by Fairbairn, Lawson, Combe and Barbour Ltd, Leeds, England.

Choosing the right speed for this oscillographic recorder is easy—just push a button and the right constant-mesh gear moves to engage a pin on the output shaft. Interlocks prevent mistakes.

Pushbutton Transmission Has Sure Touch



FIVE PUSHBUTTONS are for selecting speed of the paper-drive; sixth actuates the transmission motor switch. Mechanical latch releases depressed button when another is pushed. Interlock prevents more than one button from being depressed at a time.

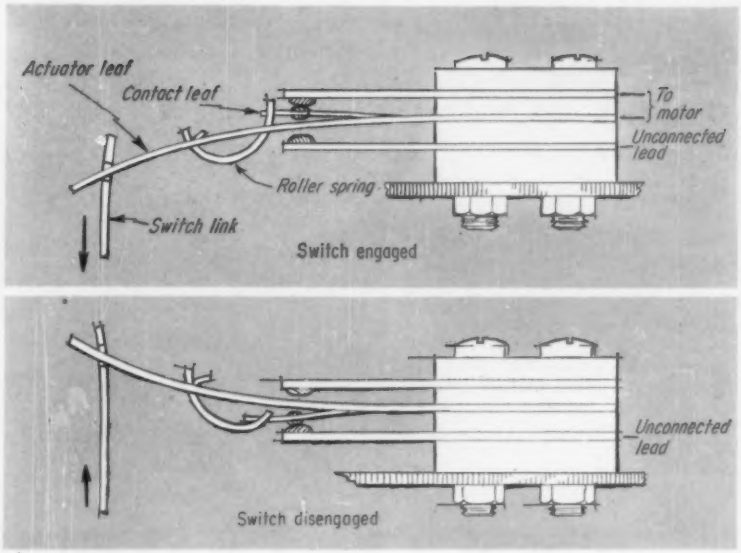
Depressing any one of the five recording-speed pushbuttons moves its pushrod down. Rack on end of pushrod engages gear segment on toggle. When toggle pivots, torsion spring forces yoke to right, bringing the clutch-gear dogs into engagement with the roll pins inserted in the output shaft. This drives shaft at the selected speed.

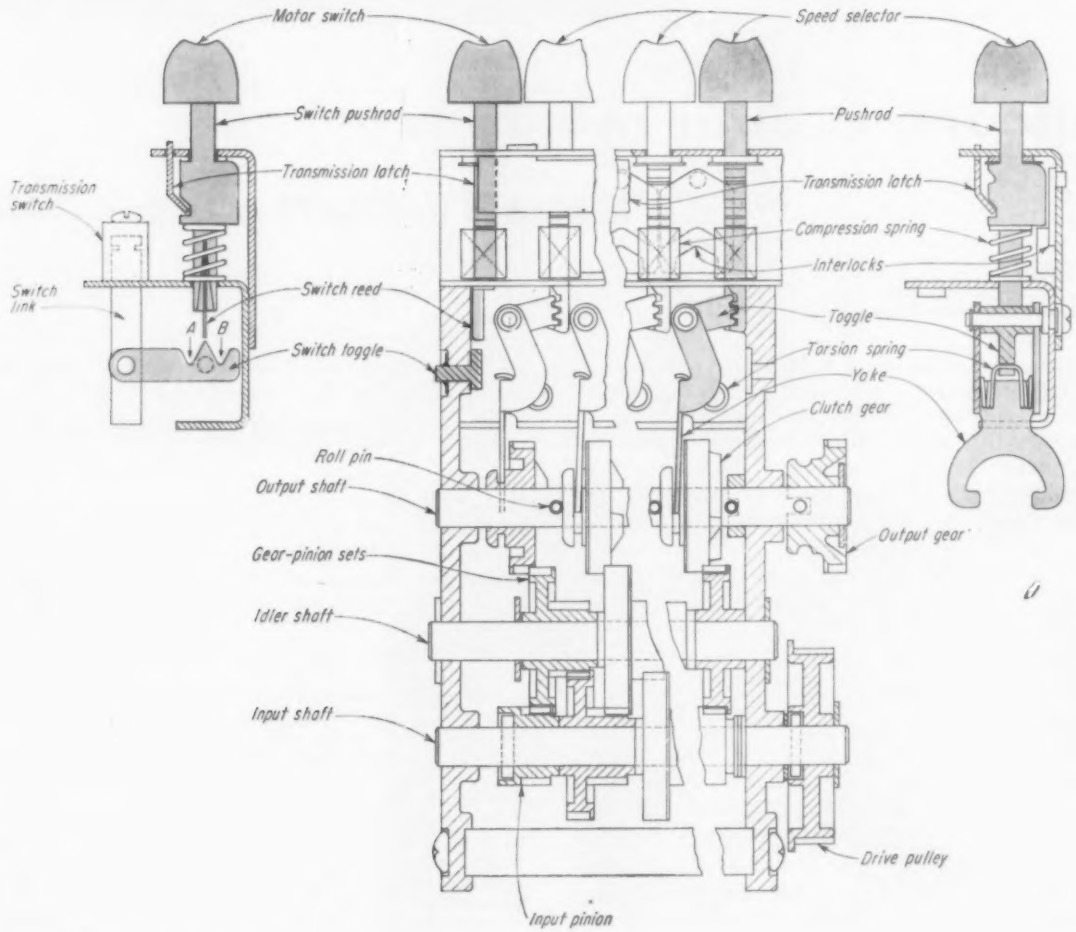
Drive pulley receives power from drive motor through a toothed belt. This power is transmitted to the input pinion which is pinned to the input shaft. Intermeshed gear-pinion sets, which rotate freely on the input and idler shafts, provide the primary gear reductions. Meshed clutch gears, which rotate freely on output shaft until moved into contact with roll pins, supply the final reduction.

Initial movement of the pushrod raises the spring-loaded latch, which permits compression spring to raise any other pushrods which have been depressed. Depression of any pushrod displaces the cam surfaces of four plastic interlocks into the path of all other speed-selection pushrods. When changing speeds, the depressed pushrod must be returned to its top position and the interlocks freed before clutch gear can engage.

PS . . . Front-loading, 18-channel oscillographic recorder operates on 115-v 60-cycle current. Light source for galvanometer illumination is an automatically regulated mercury-vapor lamp. Recorder produces 7-in.-wide record by printout without treatment or chemical processing. Individual input for each channel can record static or dynamic data from dc to 5000 cps. Complete unit weighs 40 lb, measures 7⅜ in. high, 13 in. wide, 15¼ in. long. Type 5-124 Recording Oscillograph is produced by Electro Mechanical Instrument Div, Consolidated Electrodynamics, Pasadena, Calif.

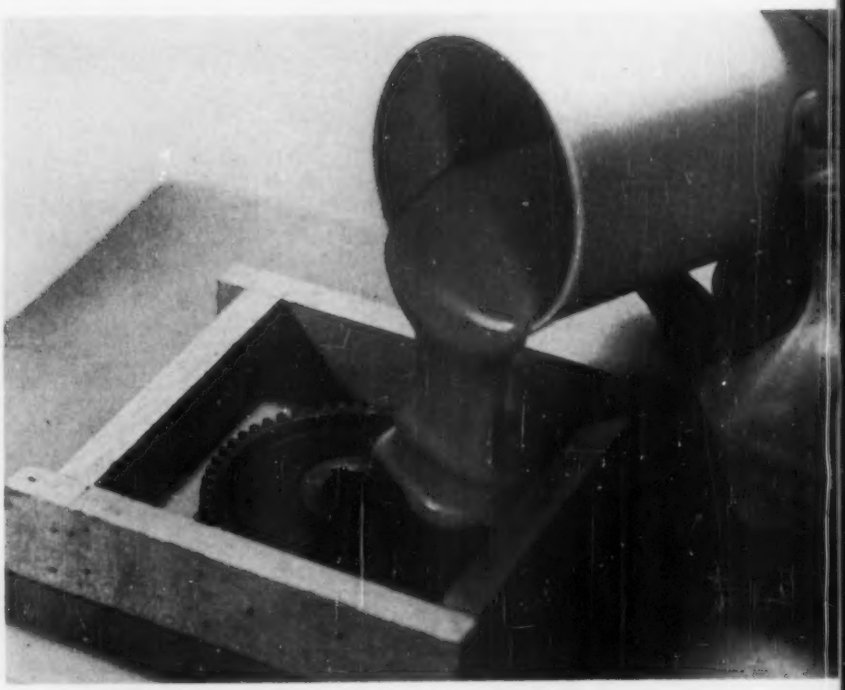
TRANSMISSION SWITCH is a press-to-start, press-to-stop type with snap-action leaf-mounted contacts. Only one set of contacts is connected. Either set may be used. For descriptive purposes upper set of contacts shall be assumed to be connected to transmission motor. Initial movement of the switch pushrod lifts the latch, releasing any speed-selection pushrods, and disengaging all clutch gears. As the switch pushrod travels down, the reed strikes the toggle cam, causing it to pivot. If, for example, the reed contacts left-hand face *A* of the toggle cam (see motor-switch detail in sketch below), the switch link is pulled down, depressing the actuator leaf. When the actuator leaf flexes down, the roller spring snaps the contact leaf up, closing the upper contacts. Switch is now engaged—its spring keeps switch link and toggle arm depressed. With toggle depressed, opposite face *B* of the cam, is beneath the reed. When switch pushrod is pressed again, the reed contacts face *B* of the toggle cam, and switch link is pushed up. This pushes actuator leaf upward and switch roller spring snaps contact leaf down to contact lower unconnected position, turning motor off.





4 STEPS GIVE MOLDS FOR METAL OR PLASTIC PARTS

1 Pour the catalyzed fluid silicone rubber into a simple form containing the part to be reproduced. Gear shown here could be any part requiring duplication. RTV silicone rubber flows readily, faithfully reproduces even finest detail. Mold forms for containing the fluid silicone rubber can be improvised from many materials. After pouring, let cast mold stand at room temperature for 24 hr until the fluid vulcanizes to a firm, rubbery solid. The pattern may now be removed, leaving the rubber mold.



silicone rubber molds for SHORT-RUN CASTINGS

H A SMITH
Silastic Fabrication Laboratory
Dow Corning Corp, Midland, Mich

Fluid silicone rubber can make flexible molds and patterns for casting metal or plastic parts cheaply and quickly. These are room-temperature vulcanizing (RTV) silicone compounds—fluid rubbers that, when catalyzed, cure into firm, rubbery solids in 30 minutes to 24 hours without external heating.

This method of mold-making can assist product development in five ways:

- A small number of prototype parts can be quickly cast for test samples. Design changes can be quickly incorporated by making new molds.
- A succession of metals and plastics can be cast and compared, once part shape is set.
- Semiproduction quantities can be cast cheaply, in multiple molds.
- Molds can be made from delicate, heat-sensitive patterns—fluid silicone rubber cures at room temperature, and linear curing shrinkage is less than 0.5%.
- Duplicate parts can be cast to ensure continued operation of a machine while a replacement part is being ordered. In some circumstances, a broken part can be used as the pattern in making the RTV silicone rubber mold for casting the replacement part.

Size is limited somewhat by the cost of the fluid rubber —about $4 per lb in lots of 100 lb or over. Note that the gear castings produced as shown in these pictures have one flush side. To get the true web geometry of the gear, a split mold would have to be made, probably using one side of the gear rim as the parting line. All silicone molds shown here were made with Silastic RTV, Dow Corning's fluid silicone rubber that vulcanizes at room temperature.

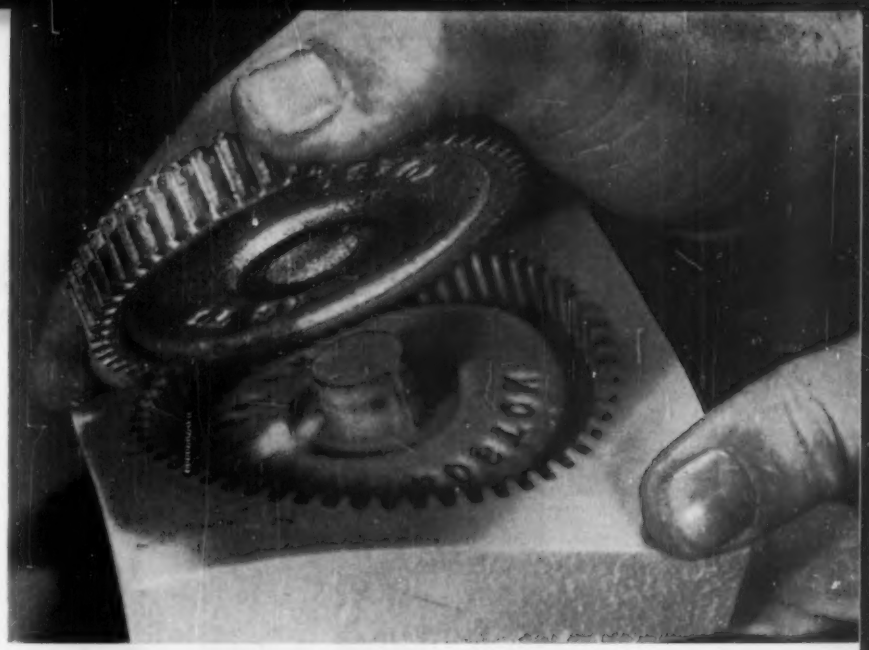
EDITOR'S NOTE: Other recent articles dealing with cast plastics include the following:

Epoxy Parts Cast by Centrifugal Force, May 23 '60, p 45—How to get precision plastic parts in quantities that do not justify high tooling cost of injection molding.

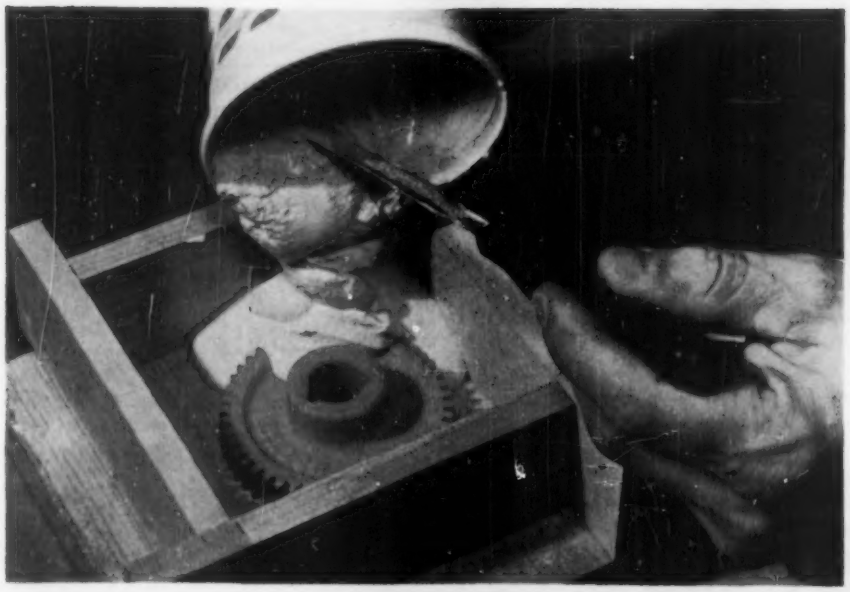
Speed Your New Product with Cast Epoxy Models, Dec 21 '59, p 60—How to convert your new-product ideas quickly and directly into actual parts or assemblies.

Epoxy Castings, June '57, p 135—Covers characteristics of casting resins and how epoxies fit in; how to design large castings as low-cost alternatives to metal parts.

Cast Urethane Rubber, Sep 16 '57, p 68—Reviews German experience with this abrasion-resistant elastomer, gives property data, and shows how to design parts properly.

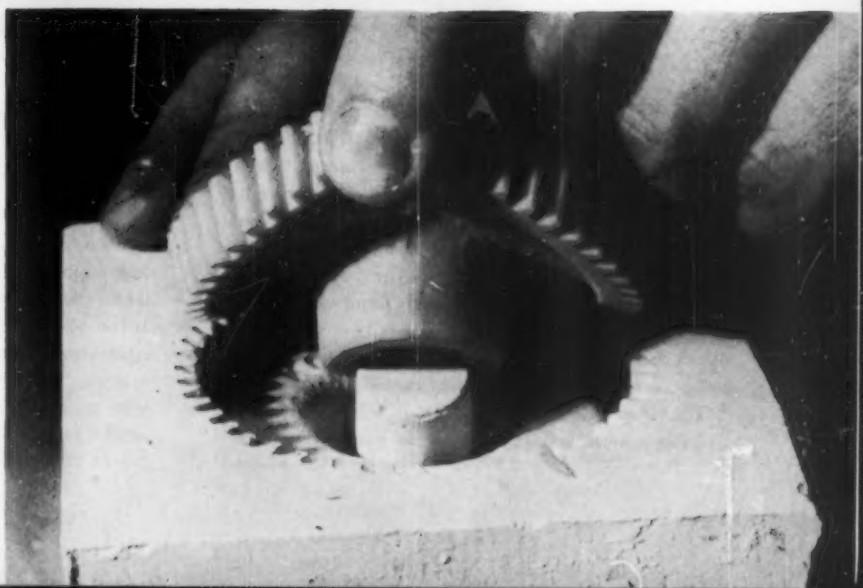


2 **Cast the part desired directly into the RTV mold for pouring temperatures under 500 F.** Flexibility of mold permits easy removal of the cast part (right) as well as the original pattern. These silicone rubbers have inherent release properties; most low-melting alloys and thermosetting resins can be cast in RTV silicone molds without any parting agent. Complex parts with deep draws may require a 3 to 5% household detergent solution, sprayed on a warm mold, to prevent sticking. When casting an RTV silicone rubber part into the RTV mold, use the detergent solution for simple shapes, or a 3 to 5% solution of paraffin wax in xylene (air-dried) for complex parts with deep draws.



3 **For casting alloys with melting temperatures above 500 F, pour a plaster mold** around an RTV rubber pattern cast from the rubber mold. Use a high-temperature metal-casting plaster such as Hydroperm, a US Gypsum Co material good for 2000 F. This will handle most aluminum and magnesium alloys. Ordinary plaster of paris can be used in emergency, but has poor resistance to thermal and mechanical shock.

4 **Remove the rubber pattern and cast the final part into the plaster mold.** Flexibility of pattern and its nonsticking surface makes removal simple in most cases. With complex shapes (such as this gear) or deep draws, the rubber positive should be coated with detergent parting agent before casting the plaster mold, then be gently eased out of the mold to avoid cracking. Rubber pattern can be used to make any number of plaster molds. A parting agent is not required on the plaster mold since very slight shrinkage on cooling is sufficient to separate final part and mold. Dimensional differences between original and final metal part are very small because of the low rubber shrinkage.



How American Industry Points The Way To Sustained Prosperity in 1961

Something new and very constructive is happening in American industry. It promises to add a major element of strength to business not only in 1961 but right along over the years ahead.

What is happening is essentially this. **American industry is planning to continue to invest heavily in new and better producing facilities in spite of the fact that it has an excess of capacity to produce its present range of products. And, by doing so, business is helping to shape a stronger American economy.** For the continuation of a high level of capital investment by business is one of the most important keys to sustained prosperity.

News of this major new development in American industry is provided by the results of the McGraw-Hill Fall Survey of Business Investment Plans for 1961 and 1962, presented in detail at the right. The McGraw-Hill investment surveys, now in their 13th year, cover a broad cross-section of American industry.

How American industry is aiming to go ahead with a big investment program in spite of its present burden of excess producing capacity is highlighted by the plans of manufacturing companies. The McGraw-Hill fall survey finds that, on the average, these companies are using slightly less than 80 per cent of their producing capacity. They would like to be using well over 90 per cent.

Dramatic New Departure

If historic investment patterns were being followed, our manufacturing companies, with only about 80 per cent of their capacity being employed, would be cutting back new investment programs drastically, and cutting down prosperity in the process. **But — and here is the dramatic new fact — they plan almost no cut-backs in their investment programs.** They plan to invest almost as much (within 3%) in 1961 as they are investing this year. And this year they are investing 19 per cent more than they did in 1959.

There are two major reasons why American industry is unwilling to let its excess producing capacity stall its investment in new facilities until the capacity is more fully used. One is that a lot of this capacity is obsolete and costly to operate. Increasingly rugged competition is creating a strong inducement to replace this antique capacity with modern, more efficient equipment which is widely available.

PLANS FOR CAPITAL SPENDING
(Billions of Dollars)

INDUSTRY	1959 Actual*	1960 Estimated*	1961 Planned	1960-1961 % Change	1962 Planned
Iron and Steel	$1.84	$1.52	$1.37	—10%	$1.18
Nonferrous Metals	.31	.34	.34	0	.32
Machinery	.91	1.15	1.11	— 3	1.11
Electrical Machinery	.52	.62	.68	+10	.63
Autos, Trucks & Parts	.64	.89	.95	+ 7	1.02
Transportation Equipment (Aircraft, Ships, R.R. Eq'pt.)	.39	.41	.37	—10	.35
Other Metalworking	.88	.97	.85	—12	.87
Chemicals	1.24	1.61	1.64	+ 2	1.59
Paper and Pulp	.63	.75	.69	— 8	.53
Rubber	.19	.24	.23	— 4	.20
Stone, Clay and Glass	.53	.63	.56	—11	.55
Petroleum & Coal Products	2.49	2.45	2.52	+ 3	2.50
Food and Beverages	.82	.94	.99	+ 5	.97
Textiles	.41	.53	.42	—21	.40
Miscellaneous Manufacturing	1.07	1.28	1.21	— 5	1.13
ALL MANUFACTURING	12.07	14.33	13.93	— 3	13.35
Mining	.99	.99	.90	— 9	.89
Railroads	.92	1.04	.79	—24	.83
Other Transportation & Communications	4.69	5.20	4.61	—11	4.18
Electric And Gas Utilities	5.67	5.89	6.14	+ 4	6.01
Commercial (1)	8.21	8.61	8.70	+ 1	8.54
ALL BUSINESS	32.55	36.06	35.07	— 3	33.80

*U.S. Department of Commerce, Securities and Exchange Commission, McGraw-Hill Department of Economics

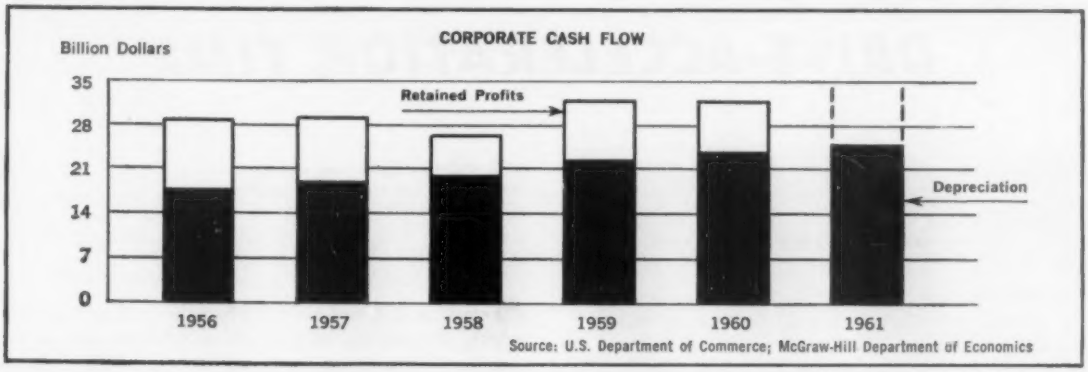
(1) Figure based on large chain, mail order and department stores, insurance companies, banks and other commercial businesses.

"R And D" Paves The Way

The steel industry provides a good case in point. Despite an operating rate of little more than 50 per cent during the last six months, steel companies plan a total investment of nearly $1.4 billion in 1961. And though this is 10 per cent below their capital expenditures in 1960, it will still be the third highest year on record.

incentive and wherewithal to continue a vigorous program of new investment. In addition, if price inflation were to begin surging again, it would eat away the power of depreciation reserves to purchase new plant and equipment.

The allowances now permitted American industrial firms for the depreciation of their producing facilities are lower than those made in any of the industrial



Also, new investment is required to tool up for the manufacture of the new products being spawned by the continuing boom in industrial research and development. This year, we are spending about $13 billion (that's *billion*) for all research and development, about $9.6 billion of it through industry.* And out of it is coming the "know-how" for a veritable flood of new products, processes and equipment, most all of these calling for new producing equipment. Next year, American manufacturers plan to get 12 per cent of their sales in products that did not even exist four years ago.

Key Role Of Depreciation Reserves

A major reason why American industry can combine the desire to carry out big new investment programs with the necessary financial capacity to do it is to be found in the growth of its reserves for depreciation. This year, (1960), business has been in a squeeze between costs and the prices it could get for its products. This cost-price squeeze has reduced profits sharply. The total of profits for the year will be down about 5 per cent.

Allowances for the depreciation of existing plant and equipment, however, have continued to rise. The result is that the so-called cash flow of corporations (their retained profits plus their allowances for depreciation) is the same this year as last. And this cash flow, shown in the chart above, makes a decisive contribution to financing new investment.

Inflation Would Be Deadly

If the sort of profit squeeze that has prevailed this year were to become chronic, it would blight both the countries with which we are in increasingly tough competition. More adequate allowances would speed up the job of modernizing American industry. An earlier McGraw-Hill survey indicated that it would cost only slightly less than $100 billion to bring our nation's plant and equipment up to date.

But at this juncture, American industry's eagerness and capacity to maintain a high level of investment capital is adding a great new element of constructive strength to the nation's economy.

---

*The significance of this boom for American industry is analyzed in a new McGraw-Hill book, "The Research Revolution" by Leonard Silk, Economics Editor of BUSINESS WEEK. Together with other new business investment trends the "R & D" boom also constitutes a key part of another new McGraw-Hill book, "New Forces in American Business" by Dexter M. Keezer and associates — the November selection of the Business Book Club.

This message was prepared by my staff associates as part of our company-wide effort to report on major new developments in American business and industry. Permission is freely extended to newspapers, groups or individuals to quote or reprint all or part of the text.

Donald C. McGraw

PRESIDENT

McGRAW-HILL PUBLISHING COMPANY

In selecting motors for special duty cycles these simple tests determine

DRIVE-ACCELERATION TIME

V B HONSINGER, *chief engineer*
Development Lab, Norwood (Ohio) Works
Allis-Chalmers Mfg Co

PARAMETERS OF DUTY CYCLE

In selecting motors for special duty cycles—reversing service, low-torque starting, fluctuating loads, constant acceleration—these seven points define the duty cycle.

1. WK^2 of the connected load referred to the motor shaft.
2. Load horsepower and length of time for each period of running.
3. Time standing idle.
4. Frequency of starts, stops, reversals, or speed changes.
5. Where stops are involved, are they by mechanical brake, dynamic braking, plugging, or coasting?
6. Friction torque of the load, when it must be brought up to speed in a fixed time. If load torque varies appreciably with speed (as in a fan drive) calculation of acceleration time requires the speed-torque characteristics of the load.
7. Any unusual requirement, such as space limitations, high ambient temperature, or need for high torque to prevent the motor from pulling out during a momentary excessive load.

Selection of a motor on the basis of acceleration time—which depends on load inertia as well as load torque—may be solved, excluding the effect of environmental conditions, by the differential equation governing the rotation of rigid bodies:

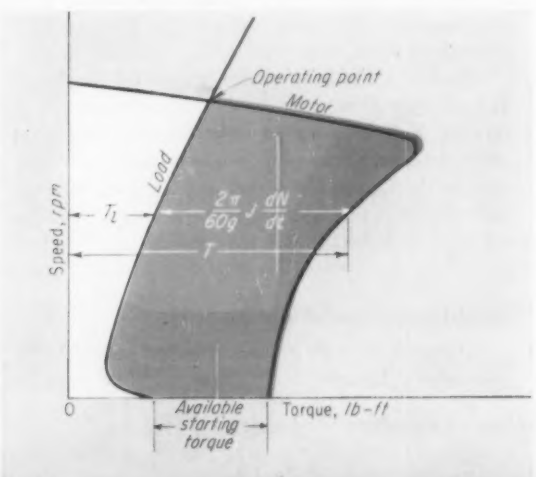
$$T = T_l + \frac{2\pi}{60g} J(dN/dt)$$

In the torque-speed curve for a typical system the net torque available to drive the system is the motor torque T less the load torque T_l. The acceleration (dN/dt) and the inertia J thus determine acceleration time, and the area enclosed by the load and motor torque curves represents the accelerating ability of the system.

Usually, the torque-speed curve of the load has a spur near zero speed caused by static friction; this is the breakaway torque required to start the machine. The available torque $T - T_l$ sets the system in motion and accelerates it to the point of intersection of the two curves at steady full-load speed.

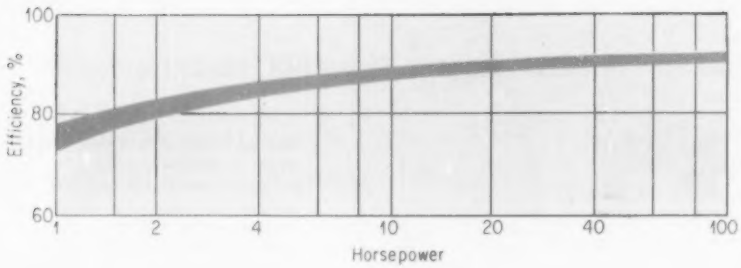
The running load and inertia of the drive can be measured by relatively simple tests requiring only a voltmeter, ammeter, wattmeter, tachometer and stopwatch.

Equations for steady state and deceleration, derived from the basic acceleration equation, are:



TORQUE-SPEED CURVE FOR A TYPICAL DRIVE. Accelerating torque at any speed is the difference between motor torque and the load torque at that speed. Colored area discloses accelerating ability of the system.

REPRINTED—Circle P75, inside back cover



EFFICIENCY of typical 60-cycle NEMA motors, for speeds from 900 to 3600 rpm.

Steady State $(dN/dt = 0)$

$T = T_l$

Deceleration $(T = 0)$

$$T_l = \frac{2\pi}{60g} J(dN/dt), \quad \text{or} \quad J = \frac{-60T}{2\pi\,(dN/dt)}$$

With these equations, relatively simple tests will measure:

1. The load torque T_l at the normal operating point.
2. The moment of inertia J of the system.
3. Speed-torque curve of the load.
4. The speed-time or acceleration-time curve of the system.

Load torque at steady state is equal to motor torque, and is determined by measuring the watts input to the motor. The load torque T in lb-ft is:

$$T = \text{Watts} \times \frac{7.04n}{N}$$

Value for motor efficiency n is obtained from the accompanying curve for induction motors around full-load. Load horsepower P is:

$$P = \frac{T_L N}{5250} = \text{Watts}\,\frac{n}{746}$$

This value of torque at speed N (in terms of the motor) is the figure needed by the motor supplier. If the motor is belted or geared to the load, the torque, as seen by the load, is increased or decreased by the drive ratio.

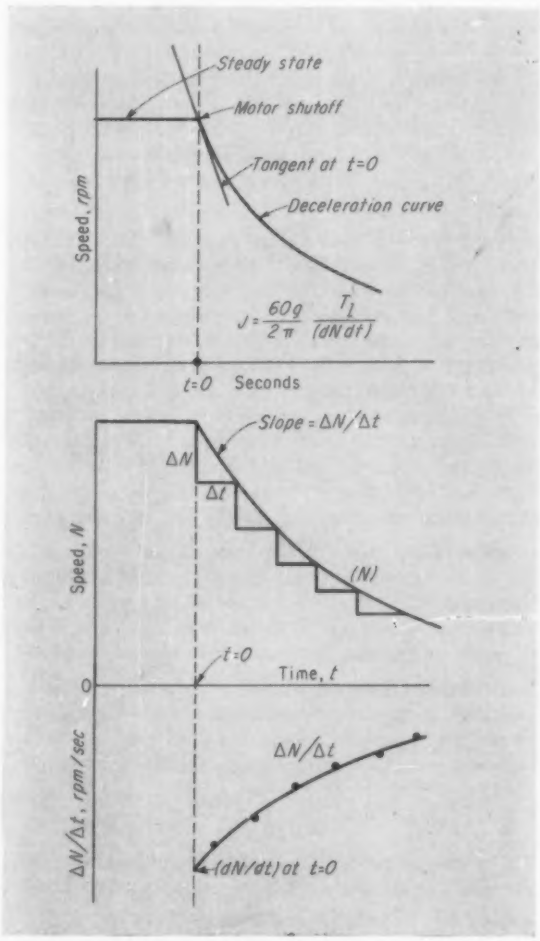
Moment of inertia can be measured by taking a deceleration curve—plot of speed in rpm and time in sec—after the motor is shut off. The slope of the curve (dN/dt) gives the deceleration at any particular speed. At the instant the motor is shut off,

$$J = \frac{60g}{2\pi}\,\frac{T_l}{(dN/dt)}$$

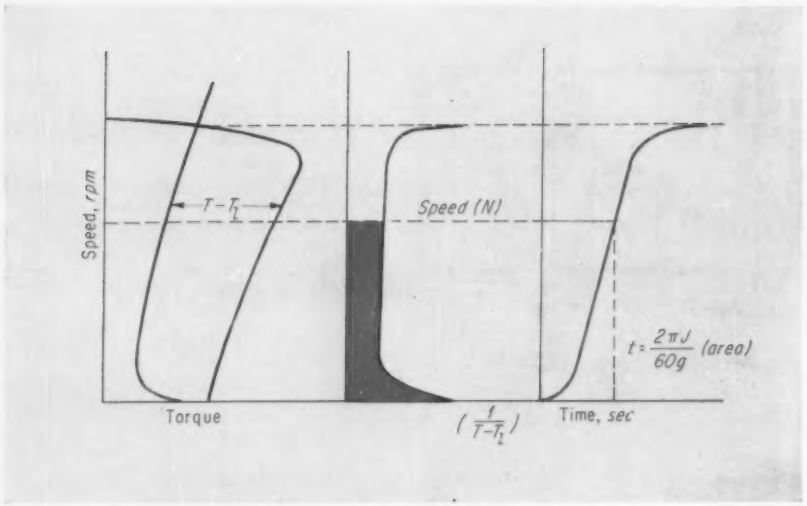
text continued, next page

SYMBOLS

- g = acceleration constant, 32 ft/sec/sec
- J = moment of inertia, lb-ft/ft, of system—motor plus load
- N = motor speed, rpm
- n = motor efficiency
- T = motor torque, lb-ft, at a given speed
- T_l = load torque, lb-ft, at the same speed
- t = time, sec



MOMENT OF INERTIA OF THE SYSTEM can be calculated from slope of the tangent to the speed-time deceleration curve at the instant of power shutoff. For greater accuracy the deceleration can be calculated at short intervals, plotted against time and extrapolated to zero time.



ACCELERATION TIME FOR THE SYSTEM can be obtained graphically by this method of integrating the speed-torque curves of motor and load. Net torque value (left) is inverted and plotted against speed (center), and the area under the curve is plotted for each speed to give acceleration time.

If deceleration takes 10 sec or more, the deceleration curve may be taken with a stopwatch and speed indicator. For loads which decelerate faster, an oscillograph can be used with a tachometer generator. Speed can be measured at either the motor or load, but if measured at the load the calculated value of J (inversely proportional to the square of the speed) must be referred to the motor shaft.

If greater accuracy is needed than can be obtained by drawing the tangent to the deceleration curve at the point where the motor is shut off, subdivide the deceleration curve into equal time intervals, calculate the slopes, plot a deceleration curve, and extrapolate to the starting point.

Speed-torque curve of the load may be useful for special acceleration conditions. Using values of dN/dt from the deceleration curve, T_t is calculated for a range of speeds and plotted against speed. If the speed-time curve is linear or nearly so, the load is constant with respect to speed.

Acceleration-time curve can be obtained from the deceleration curve if the speed-torque curve of the motor is known together with the speed-torque curve of the load and inertia of the system. Integrating the equation for T,

$$t = \frac{2\pi J}{60g} \int_0^N \frac{dN}{T - T_t}$$

The integral can be solved when the speed-torque curves T and T_t are known. If $T - T_t$ is constant, the value of the integral is

$$t = \frac{2\pi J}{60g} \frac{N}{T - T_t} = \frac{J}{308} \frac{N}{(T - T_t)}$$

Where $T - T_t$ is not constant and graphical values of T and T_t are available, the integration can be performed graphically in the three steps shown above. First, the motor and load speed torque curves are plotted; then the reciprocal acceleration torque $1/(T - T_t)$ at each speed N is plotted; and finally the area formed by the curve (colored area in figure) at each speed N is measured and multiplied by $2\pi J/60g$. This is the time to accelerate to speed N.

Environment is Important

Acid erosion, caustic attack, severe vibration, excessive moisture and humidity, variations in temperature, abrasion by solid particles, electrical and mechanical stresses, shock forces, and oil contamination are a few factors that may be encountered. To sharpen judgment when dealing with these problems, first consider those physical byproducts of the output which leave the motor—the quality of service performed by the motor; and then those factors which enter the motor and affect motor life. Heat is an exception: it is a byproduct of the output which limits the life of a motor.

Service performed. A motor driving a compressor may transmit undesired vibrations through the motor base. A pump motor may transmit torsional vibrations to the pump impeller and the piping, generating unwanted noise. Motors generate electromagnetic radiation, or heat which affects products, or sparks which cause explosions.

Motor life. Substances which enter the motor—corrosion gases and liquids, solid particles, and vibrations—limit motor life by attacking insulation. Another factor is heat—for each 8 to 10 deg C rise in temperature the insulation life is halved. Operate a class A motor continuously at an overload of about 15% and the increased temperature of about 10 deg C will cut motor life in half.

For REPRINT of above article, just check P75 on one of the Reader Service cards found in this issue.

EDITOR'S NOTE: Recent articles offering design assistance in selecting motors for duty-cycle conditions include:

Which Heat Protector for the Motor, Sep 12 '60, p 53—Characteristics and limitations of inherent thermal-protection systems for motors even when duty cycle is not readily predictable.

The Significance of WK² and How to Calculate It, June 27 '60, p 39—Methods for computing inertia of the system referred to the motor shaft for linear and rotary motion, and torque-speed curves for NEMA Design D motors.

For several earlier articles, see the list published June 27, 60, p. 46.

Calendar Gives Fast Look-ahead

With it you can find the interval between two work-program dates by one quick subtraction.

O K GRADE, *senior methods engineer, Machlett Laboratories Inc, Springdale, Conn*

If you number the days of the week and the weeks of the year as in the revised calendar below, you can key your work program with production schedules. A little mental arithmetic is all you need to find time between two dates.

EXAMPLE I: A decision for design modifications is made Jan 16. Production of the redesigned product is to begin July 21. How much time do you have?

SOLUTION: Jan 16 is number one day in the third week, or 3-1. July 21 is number five day in the 29th week, or 29-5. Intervening period is 29-5 minus 3-1 or 26 weeks, 4 days.

EXAMPLE II: Watch out for cases like this. How long a time is there between Jan 20 and Mar 13?

SOLUTON: Jan 20 is 3-5. Mar 13 is 11-1. But 11-1 minus 3-5 is not 7 weeks, 6 days; it is 7 weeks, 3 days.

If the second date is in the next year, add 52 to the week number: Jan 3, 1962 becomes 53-3.

1961

Month	Working week	S 0	M 1	T 2	W 3	T 4	F 5	S 6
January	1	1	2	3	4	5	6	7
	2	8	9	10	11	12	13	14
	3	15	16	17	18	19	20	21
	4	22	23	24	25	26	27	28
February	5	29	30	31	1	2	3	4
	6	5	6	7	8	9	10	11
	7	12	13	14	15	16	17	18
	8	19	20	21	22	23	24	25
March	9	26	27	28	1	2	3	4
	10	5	6	7	8	9	10	11
	11	12	13	14	15	16	17	18
	12	19	20	21	22	23	24	25
	13	26	27	28	29	30	31	1
April	14	2	3	4	5	6	7	8
	15	9	10	11	12	13	14	15
	16	16	17	18	19	20	21	22
	17	23	24	25	26	27	28	29
May	18	30	1	2	3	4	5	6
	19	7	8	9	10	11	12	13
	20	14	15	16	17	18	19	20
	21	21	22	23	24	25	26	27
	22	28	29	30	31	1	2	3
June	23	4	5	6	7	8	9	10
	24	11	12	13	14	15	16	17
	25	18	19	20	21	22	23	24
	26	25	26	27	28	29	30	1

Month	Working week	S 0	M 1	T 2	W 3	T 4	F 5	S 6
July	27	2	3	4	5	6	7	8
	28	9	10	11	12	13	14	15
	29	16	17	18	19	20	21	22
	30	23	24	25	26	27	28	29
August	31	30	31	1	2	3	4	5
	32	6	7	8	9	10	11	12
	33	13	14	15	16	17	18	19
	34	20	21	22	23	24	25	26
	35	27	28	29	30	31	1	2
September	36	3	4	5	6	7	8	9
	37	10	11	12	13	14	15	16
	38	17	18	19	20	21	22	23
	39	24	25	26	27	28	29	30
October	40	1	2	3	4	5	6	7
	41	8	9	10	11	12	13	14
	42	15	16	17	18	19	20	21
	43	22	23	24	25	26	27	28
November	44	29	30	31	1	2	3	4
	45	5	6	7	8	9	10	11
	46	12	13	14	15	16	17	18
	47	19	20	21	22	23	24	25
	48	26	27	28	29	30	1	2
December	49	3	4	5	6	7	8	9
	50	10	11	12	13	14	15	16
	51	17	18	19	20	21	22	23
	52	24	25	26	27	28	29	30
January 1962	1	31	1	2	3	4	5	6

News! The best features of
modern bearing design combined and refined in

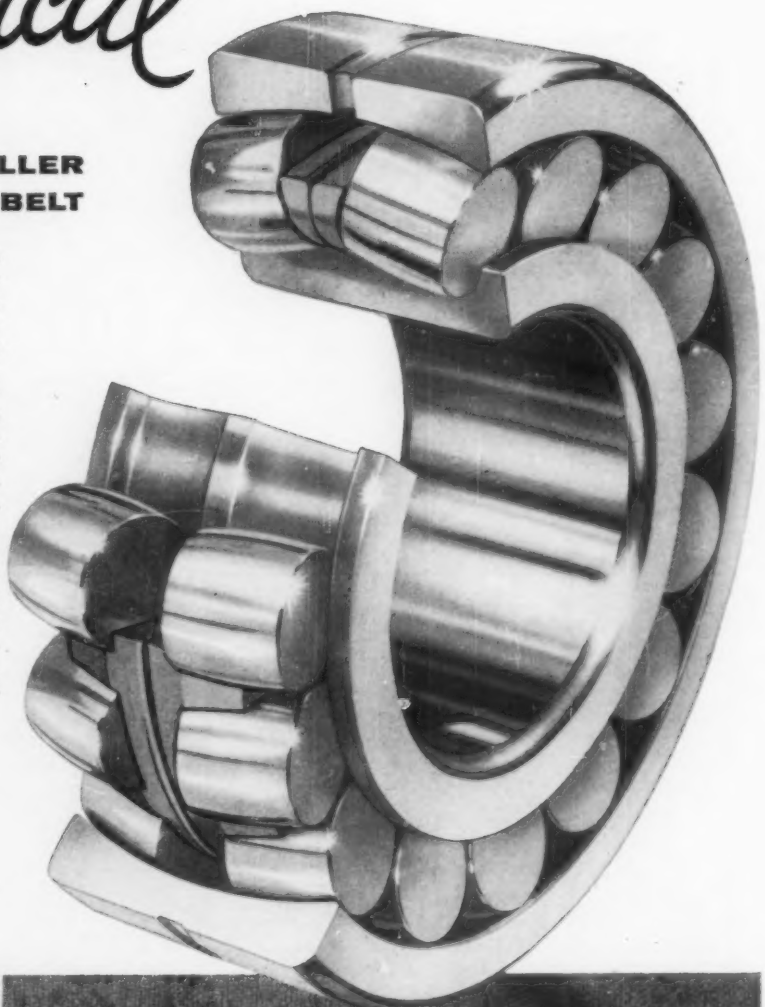
Spherical

SELF-ALIGNING ROLLER BEARINGS BY LINK-BELT

BIG, mirror-smooth convex rollers *plus* heavy, broad-shouldered inner race *plus* centrifugally-cast bronze, precision-machined retainers! Only from Link-Belt do you get ALL that is best in modern bearing design.

Individually, these elements represent major improvements on accepted design concepts. Collectively, they constitute the most efficient spherical roller bearings available . . . promise unequalled economies, whatever the application.

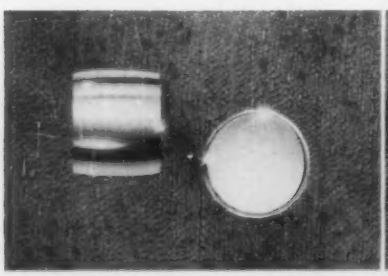
Your Link-Belt office will gladly explain the many performance advantages evolved with this new design. It can furnish full data on industry's most complete line of ball and roller bearings . . . pillow blocks and flanged, flanged-cartridge, cartridge, and take-up blocks.



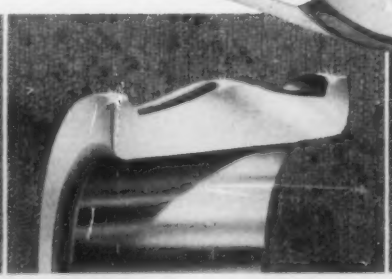
LINK-BELT

MANUFACTURERS OF SELF-ALIGNING BALL AND ROLLER BEARINGS

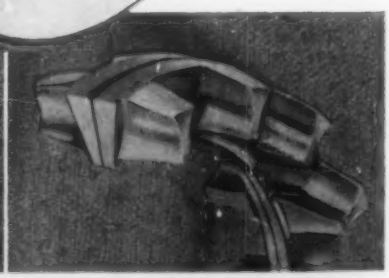
LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. Plants, Sales Offices and Distributors in All Principal Cities. 14,819-A



BIG, HIGHEST-CAPACITY ROLLERS. Each bearing has a maximum number of rollers —as large as possible, yet all components are in optimum balance.



HIGH, HEAVY INNER RACE FLANGES present convenient hold for assembly and removal of bearing without cutting away shaft, avoid any need to skimp on shaft shoulders.

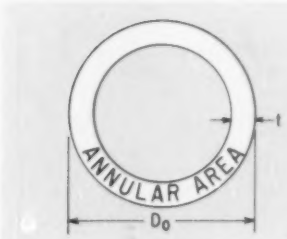


PRECISION-MACHINED, CENTRIFUGALLY-CAST BRONZE RETAINERS have many times more support and ability to withstand high stress. They are not stampings. Design assures maximum bearing efficiency.

STEEL TUBING— Its weight? Its annular area?

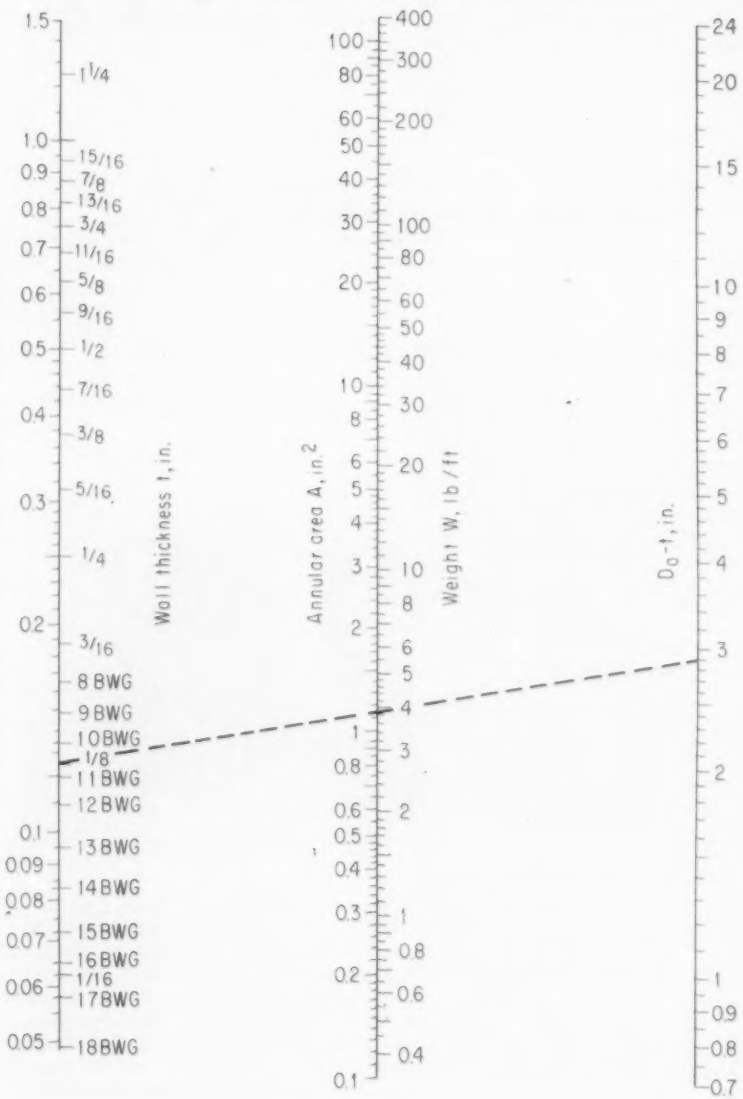
Nomograph gives quick answers, also speeds calculation of tubing shear strength.

F KAPLAN
Kaiser Engineers Div, Henry J Kaiser Co
Oakland, Calif



SYMBOLS

A	=	Annular area, in.²
BWG	=	Birmingham wire gage
D_o	=	Outside diameter, in.
L	=	Shear strength, lb
s	=	Shear resistance, psi
t	=	Wall thickness, in.
W	=	Weight, lb/ft



The designer must know the shear strength of steel tubing when it carries a load. He must also know the weight of the tubing when he is planning the lightest practical supports for it, or where weight of the equipment itself must be held to a minimum.

One line drawn on the nomograph at right gives weight per foot of steel tubing and the annular area for different sizes. Shear strength L equals annular area A times shear resistance s. For convenience, several Birmingham wire gage values have been included on the wall-thickness scale.

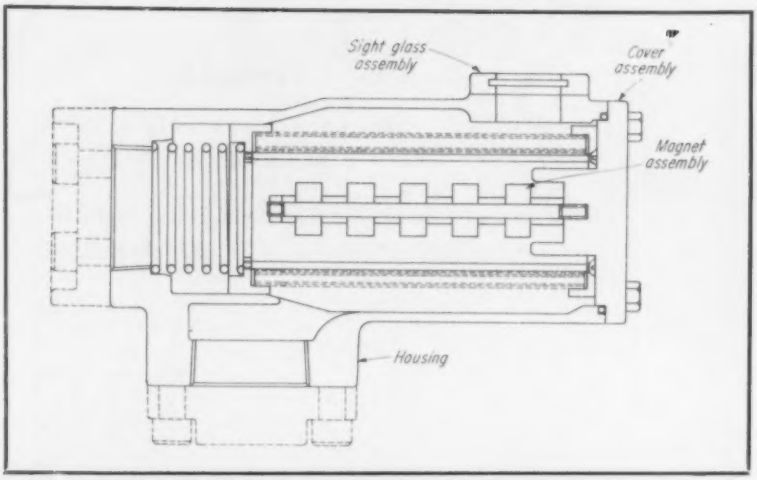
EXAMPLE: A steel tube in an airborne winch has an outer diameter of 3 in. and wall thickness of $\frac{1}{8}$ in. What shear load can it stand? How much weight will 4 ft of this tubing add to the winch?

SOLUTION: For this steel, shear resistance s is 43,000 psi. On the nomograph draw a line from $\frac{1}{8}$ in. on the left-hand scale to $D_o - t = 2.875$ in. on the right-hand scale. Annular area is 1.13 in.² and:

$$\text{Shear strength } L = As = 1.13 \times 43 \times 10^3 = 48{,}590 \text{ lb}$$

Also provided by the center scale: tubing weight is 3.85 lb/ft. Weight of 4 ft is 15.4 lb.

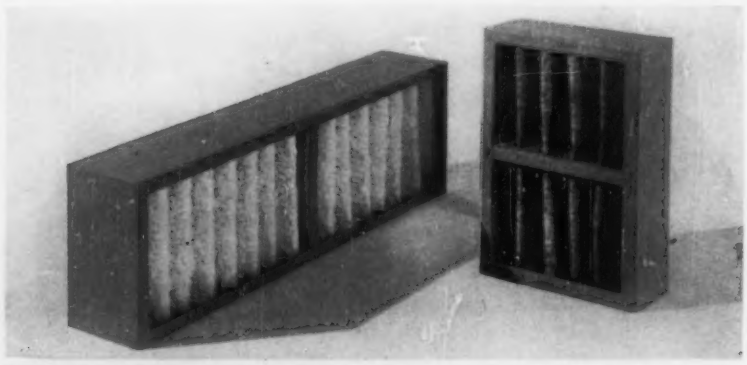
SIGNIFICANT COMPONENTS MATERIALS, PROCESSES



Filter has magnet positioned downstream . . .

of screen where velocity is lowest. This means that filter's external indicator can be arranged to signal for magnet clean-out before metal particles can form clusters or larger-than-allowable particles are passed. Pressure drop is controlled by an adjustable spring assembly so that it is kept to a 12-15 psi level. With fluids of 150 ssu, available models have flow rates ranging from 4 to 325 gpm. Prices range from approx $55 to $734, depending on model and capacity. Distribution is national. **Rosaen Co, 1776 E 9 Mile Road, Hazel Park, Mich.**

Circle 300 on Reader Service Card



Disposable interception filter . . .

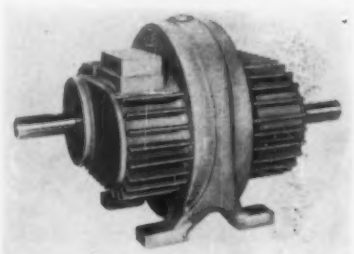
is made of pleated fiberglass mat material to provide max filter area for room recirculators, kitchen range hoods and electronic cabinet cooling. Does not require positive ionization to filter properly. Six-in. wide unit has min efficiency of 90% by N.B.S. dust spot test and average efficiency of 95%. Provides from 0.08 in. water resistance at 60 cfm to 0.52 at 250 cfm. Seven-in. wide unit is an average 80 to 85% efficient, and provides from 0.130 in. water resistance at 50 cfm to 0.460 at 125 cfm. Priced at under $10. Some standard sizes from stock; delivery in 4 wk on special sizes. **Cambridge Filter Products, 738 E Erie Blvd, Syracuse 1, NY.**

Circle 301 on Reader Service Card

Low-temperature infrared heat

is produced by catalytically-active metal screen on which LP gas energy is directly converted to infrared heat energy. Combustion occurs below flammable range. Screen itself, acting as radiant heat source, can be held to 800 to 1500 F, allowing work to be placed close by. Panels, available in standard sizes, provide heat release ranging from 2000 to 12,000 btu per hr per sq ft of emission surface. This is almost equal to 4 to 24 w per sq in. **Catalytic Combustion Corp, 4725 14th St, Detroit 8.**

Circle 302 on Reader Service Card



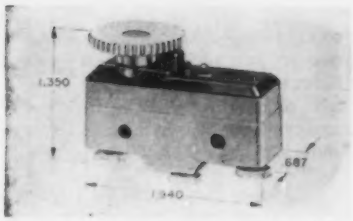
5-hp transmission . . .

for high-speed positioning and sequencing, instantly reverses in 0.2 sec under severe conditions. Engaging one of two opposing electromagnetic clutches provides chain drive; engaging the other produces gear drive. Has high degree of amplification which permits use of low-power signals in servo systems. Operates from a 110 v ac supply. Rated 5 hp at 1750 rpm, unit transmits torques of more than 250 lb-in. under transient conditions. Under steady-state conditions at any speed, it delivers 180 lb.-in. Measures 10½ x 9½ x 10½ and weighs 55 lb. Priced at approximately $495; delivered in approximately 16 wk. **Airborne Accessories Corp, Industrial Div, 1414 Chestnut Ave, Hillside 5, NJ.**

Circle 303 on Reader Service Card

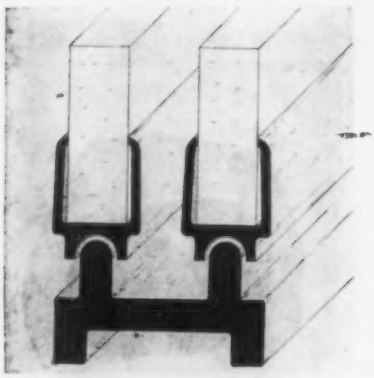
Wheel on switch top . . .

adjusts differential travel within 0.0025 to 0.007 in. Changing differential travel likewise changes contact break distance, pretravel distance and operating and differential forces. Operating force varies from 12 to 32 oz, and differential force from 2 to



15 oz. Release force remains at 10 oz, regardless of differential setting. Switch is rated at 20 amp at 120, 250 or 460 v ac; ¾ hp at 115 v ac; and 1½ hp at 230 v ac. Said to last for over 5 million operations. From stock at $3.50 each. **Micro Switch Div, Minneapolis-Honeywell Regulator Co, Freeport, Ill.**

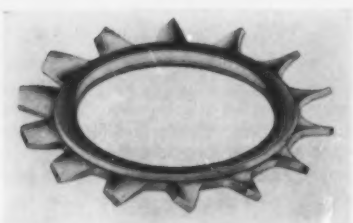
Circle 304 on Reader Service Card



Two-part sliding-door track

eliminates metal-to-metal and glass-to-metal contact encountered when sliding doors or panels ride directly on plastic track. "Female" profile on sliding door rides on "male" track which is fastened to cabinet. Glide extrusions, made of high-impact styrene, are snap-fitted, eliminating fasteners or cement. Priced at approximately 10¢ per ft. Delivery in 2 to 3 wk. **Anchor Plastics Co Inc, 36-36 36th St, Long Island City 6, NY.**

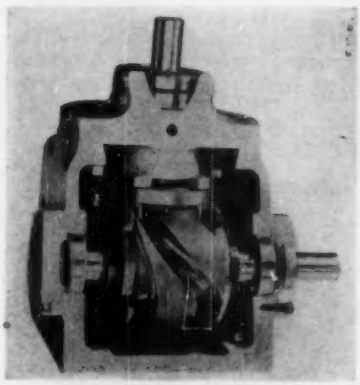
Circle 305 on Reader Service Card



Folder-rim lock washer . . .

reportedly eliminates thread leakage under 500 F. Double-layer rim is formed by turning back and crimping inside dia. Said to resist extreme fastening stresses and prevent slipping or creeping during tightening. Available for $\frac{7}{16}$ to $\frac{5}{8}$-in. screw sizes. **Shakeproof Div, Illinois Tool Works, St Charles Rd, Elgin, Ill.**

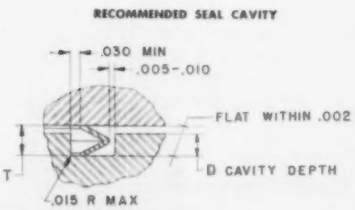
Circle 306 on Reader Service Card



Index drive has zero backlash

in dwell position. Modified trapezoid acceleration results in jerk-free intermittent drive with min vibrations even at speeds of 1000 indexes per min. Indexing accuracy is said to be within 0.001 in. Standard models, with basic load ratings of 625 to 5000 in.-lb and upwards, have preloaded, roller-bearing followers and hardened and ground tool-steel cams. Prices range from approximately $600 to $1380. Delivery in 2 wk. **Commercial Cam & Machine Co, 455 N Artesian Ave, Chicago 12.**

Circle 307 on Reader Service Card



Metallic static seal . . .

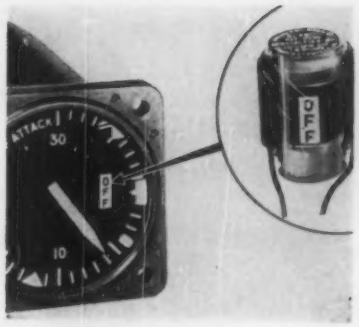
has zero leakage from a vacuum to greater than 30,000 psi at −320 to 2200 F. Can be reused up to 10 or 15 times. Sealing is attained with low flange requirements on surface finishes of 32 to 100 rms. Available from ⅛-in. to more than 3-ft dia. **Servotronics Inc, 190 Gruner Rd, Buffalo 25.**

Circle 308 on Reader Service Card

Miniature bellows . . .

and diaphragms are available with wall sections of 0.0005 to 0.005 in. in materials suitable for high-temperature, high-pressure and nonmagnetic applications. **Kinemotive Corp, P O Box 386, Huntington Station, NY.**

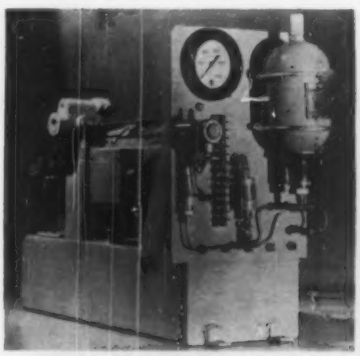
Circle 309 on Reader Service Card



Indicator with one moving part

operates magnetically through rotor floated in silicone fluid. Eliminates need for delicate springs, bearings or mechanical stops. Vacuum-sealed rotor is statically balanced about its axis and its weight is equaled by displaced fluid, making it less subject to vibration. Moves 65° in either direction, providing three possible signals. Used in circuits requiring from 1 to 220 v ac and dc. Draws 100 milliw to actuate "on" signal and returns to "off" or neutral position without external power when monitored circuit is interrupted. Can be mounted in any position. Priced at approx $13.25 each in quantities of 100; $11.75 each in quantities of 1000. Delivery in 2 wk. **Specialties Inc, Skunks Misery Rd, Syosset, NY.**

Circle 310 on Reader Service Card

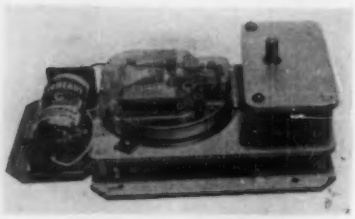


Hydraulic power supply . . .

delivers 2000 psi at 0.5 gal. per min., permitting use of smaller piston areas and valves in control system. Dry-nitrogen accumulator removes pressure surges and drops, while miniature switch regulates system pressure to ±50-psi accuracy. In event of external system failure, electric dump valve immediately reduces system pressure to zero. Can be driven from either 220- or 440-v, three-phase, 60-c. Standard models range from 1000 to 2000 psi, with flows of 0.5 to 1 gal. per min. Prices start at $800. Delivery in 60 days. **System Analysis Inc, 2305 Country Club Rd, Endicott, NY.**

Circle 311 on Reader Service Card

continued on page 62



Chronometrically governed motor . . .

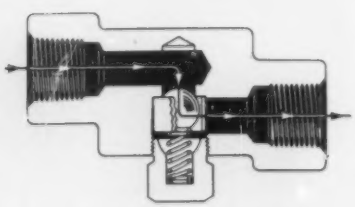
can operate for more than 2 yr on a standard flashlight battery. When used as a clock drive, a constant speed of 150 rpm is maintained by balance wheel-hairspring mechanism with an accuracy of ±10 sec in 24 hr even with 0.9 to 1.8 v input. If battery voltage is high, motor rotor automatically compensates by shutting off its own current at frequent intervals. When voltage is low, current flows to rotor for longer periods. Measures 1¾ x 2½ x ½ in. and weighs 3 oz. Available for voltages from 0.5 to 12 v dc. **A W Hayden Co, Waterbury, Conn.**

Circle 312 on Reader Service Card

Mass-production sealing . . .

of any shape or size component is possible. Sealants include: soft, dense and closed-cell sponge rubber; soft, dense plastisol; soft closed-cell vinyl; asphaltum compounds; specially compounded waxes and other elastomeric insulating materials. **Automotive Rubber Co, 12550 Beech Rd, Detroit 39.**

Circle 313 on Reader Service Card



Hydraulic, air check valve . . .

has a highly sensitive ball check to provide full flow in one direction and instant checking in reverse. Ball is confined to close limits and can move only in a vertical plane from its seat. Since ball area is double that of seat area, pressure applied over the former as it leaves its seat causes it to accelerate, giving a rapid opening at low differentials, without chatter. Operating pressure of aluminum model is 3000 psi; steel and stainless steel model, 5000 psi. Available in ⅛-, ¼-, ⅜-, ½- and ¾-in. pipe or tube sizes. **Auto-Ponents Inc, 30001 Grant St, Bell-Wood, Ill.**

Circle 314 on Reader Service Card

Solenoid-driven rotary switch

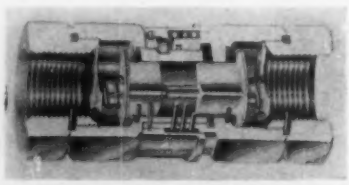
including an anti-overshoot detent mechanism, steps 360° in 30° increments and is single-pulse operated. Drive package measures 1⅝ in. long and will fit in 1½-in.-dia tube after wiring. Pulls up to 10 wafers at 60 w or less input. Wafers can be stacked back-to-back on output shaft without use of spacers. **Licon Div, Illinois Tool Works, 6606 W Dakin St, Chicago.**

Circle 315 on Reader Service Card

Infrared detector . . .

has a mean-time constant of 375 microsec and a dark-resistance range from 500 kilohm to 1.5 megohm. At normal room temperatures, cell is sensitive to visible and intermediate infrared radiation over a 0.7 to 2.7-micron range. Priced at $6.15 each in quantities of 1 doz. **Tupper Trent Co Inc, 207 Carter St, Chelsea 50, Mass.**

Circle 316 on Reader Service Card



Coupler combines O-ring, E-packer seals . . .

to prevent spray when connecting or disconnecting coupling. Metal-to-metal stop when valve is in closed position controls valve seal's compression and displacement. Coupling is available with both nipple and coupler valved for double or single shutoff. Sizes range from ¼ to 6 in. **Snap-Tite Inc, Union City, Penna.**

Circle 317 on Reader Service Card

Centrifugal pumps . . .

operate at 1750 rpm, making them suitable for low-noise-level requirements. Pumping rates range from 15 to 500 gal. per min., with heads to 110 ft. Ball-bearing motors, available in either dripproof or totally enclosed construction, are rated from ¾ to 7½ hp. Can be mounted horizontally, vertically, or at any angle between, provided motor is kept higher than pump. Sizes range from 18⅜ to 24¾ in. long and from 11⅞ to 15⅛ in. wide. **Ingersoll-Rand Co, 11 Broadway, New York 4.**

Circle 318 on Reader Service Card

Phase-shifting transducer . . .

generates continuous time delays or phase variations directly proportional to shaft rotations. Operates at speeds up to 5000 rpm at any specific frequency up to 5 mcs. Has rotor design and precision eccentric disk to cut out noise. Contains no brushes. Can be used as a function generator, frequency changer, multiple-wave phase-shifter and in frequency-response testing of feedback control systems. **Nilsen Mfg Co, PO Box 127, Haines City, Fla.**

Circle 319 on Reader Service Card

Solid-state time delays . . .

operate on 18 to 32 v dc and provide delay either on pull-in or drop-out in a total span from 0.01 sec to 10 hr. Timing ranges allow adjustment ratios of 10, 20, 40, 50, 100, 200, 1200 or 3000 to 1. Available in two ambient ranges: −67 to 158 F and −67 to 257 F, with fixed-condition accuracies of ±3 or 5%. Output can be either solid-state (up to 5 amp) or relay devices (up to 10 amp). Contain potted and hermetically sealed printed circuit panels and integral transient-suppression networks. **Elizabeth Div, Elastic Stop Nut Corp of America, Elizabeth, NJ.**

Circle 320 on Reader Service Card

All-rubber pushbutton station

is suitable for any 2-station application. Meets NEMA enclosure requirements type 1, 4 and 5 for both heavy and standard-duty operation. Has micro type 1- or 2-pole switches with normally open and/or normally closed contacts. Molded-rubber construction is said to provide operator safety, long life and corrosion-free service. **Joy Mfg Co, Electrical Products Div, 1201 Macklind Ave, St. Louis 10.**

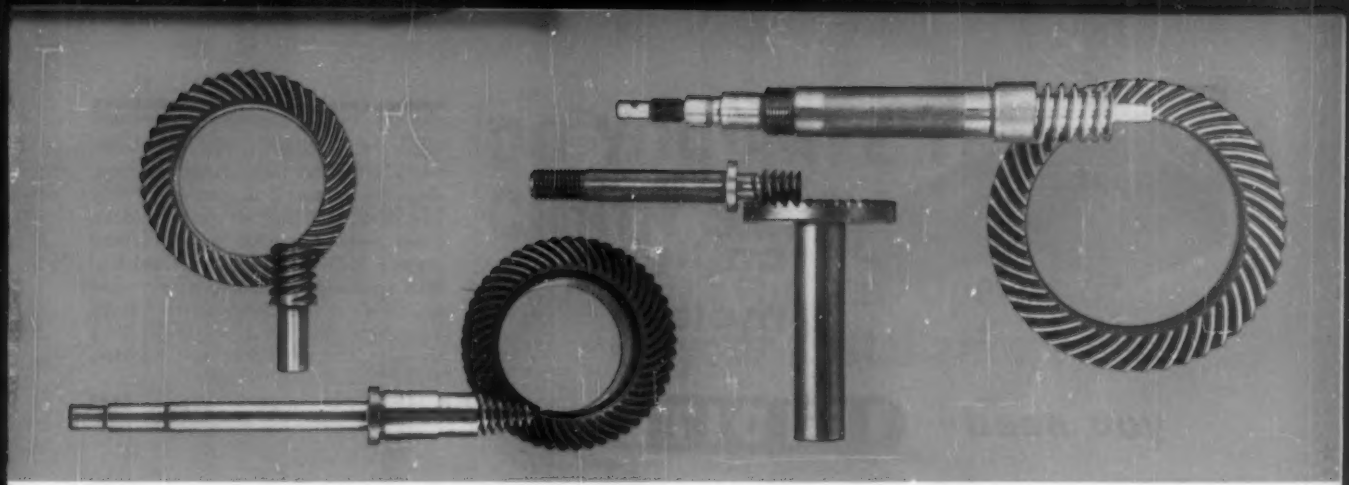
Circle 321 on Reader Service Card

Self-manifolding valve . . .

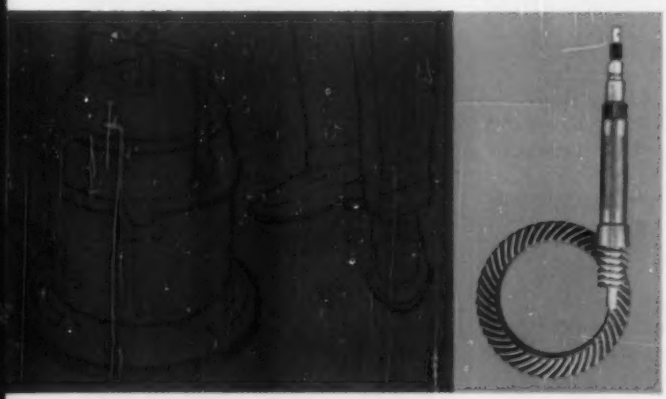
is a 3-way, 2-position, NC or NO, magnetic or manually operated unit. Has balanced poppet moving between two soft, bubbletight seats and a symmetrical body. Can be manifolded into any number of

continued on page 64

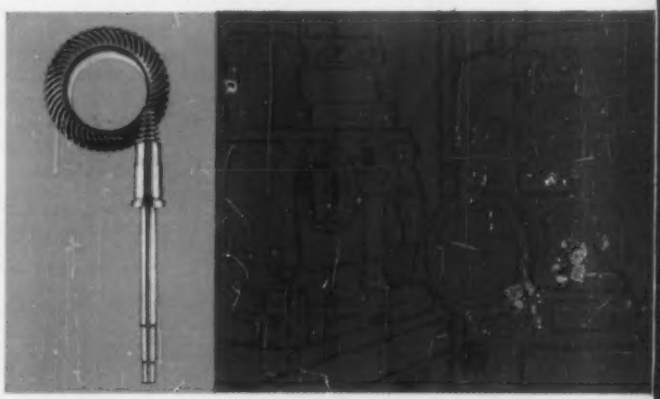
CIRCLE 63 ON READER SERVICE CARD→



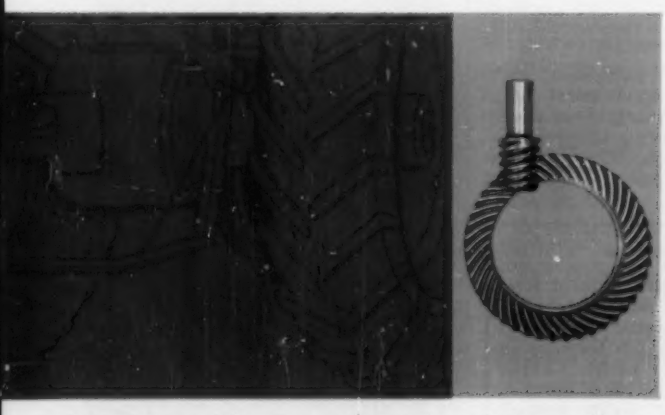
WHICH OF THESE HIGH-RATIO HYPOIDS IS "JUST RIGHT" FOR YOUR PRODUCT?



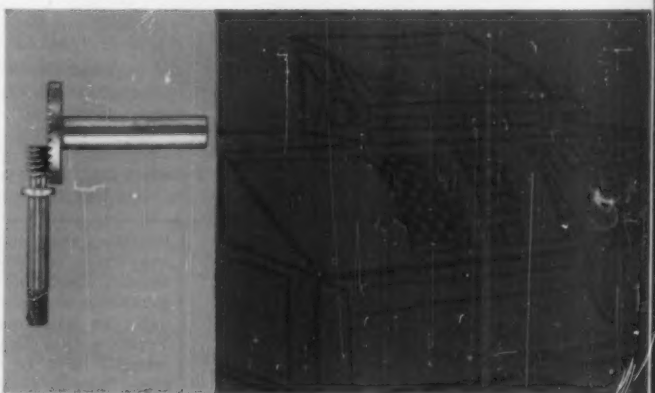
For hand tools. Where space is a problem—as in portable tools like this one—the high offset lets you design a more compact unit. Choose just the offset to solve your design problem with a more flexible, more compact unit than the corresponding worm and wheel.



. . . or machine tools. This high-offset pair lets you combine high reduction with strength, compactness and other advantages you might find profitable in designing machine tools. High-ratio hypoids can be produced on Gleason equipment for ratios of 1:10, 1:40 or even higher.



Big and strong. Where you need strength—as in farm machinery—high-offset hypoid pinions (with teeth which tend to "wrap around") are larger and stronger than corresponding bevel pinions. An extended shank on cylindrical pinions makes very rigid straddle mountings practical.



. . . or small and smooth. For smooth operation—as in office equipment that must run quietly—high-offset pairs provide smooth, quiet tooth action. Because teeth "wrap around" the pinion, you get continuous action—even with just one or two teeth! Grinders are available for applications requiring precision finish.

High-offset or high-ratio hypoids can be cut, tested, and quenched on the same Gleason equipment that is used on more familiar spiral bevel and hypoid gears. You can get more information about Gleason high-ratio hypoid gears by writing for free literature. Submit your prints for recommendations.

GLEASON WORKS

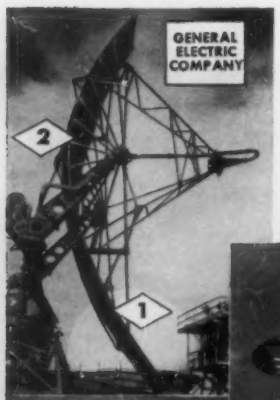
1000 UNIVERSITY AVE., ROCHESTER 3, N.Y.

LOOK FOR THE DIAMONDS—SIGN OF FINISHING QUALITY

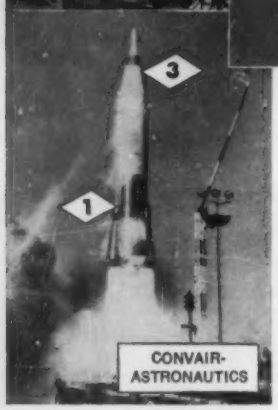
for protection on light metals

you need IRIDITE®

PROCESS ENGINEERED
CHROMATE CONVERSION COATINGS



1. Iridite protects against high altitude weather extremes and against corrosion by hydrocarbon fuels, such as gasoline and kerosene.
2. Iridite provides a highly protective non-porous paint base.
3. Iridite protects against corrosive storage conditions.



And, Iridite gives you these additional advantages:

ON ALUMINUM—needs only normal precleaning. Film withstands cold forming or bending. Easily heliarc welded. Unusually low electrical resistance. Clear, yellow or dye-colored finishes.

ON MAGNESIUM—short immersion, room temperature solution, no electrical equipment. Corrosion protection relatively unaffected by high drying temperatures. Applicable to all alloys. Low electrical resistance. Color ranges from light gray to dark brown.

IRIDITE—a specialized line of chromate conversion coatings for non-ferrous metals. Easily applied at room temperatures with short immersion, manually or with automatic equipment. Forms a thin film which becomes an integral part of the metal. Cannot chip, flake or peel; special equipment, exhaust systems or highly trained personnel not required.

For complete information on Iridite, contact your Allied Field Engineer. He's listed under "Plating Supplies" in the yellow pages. Or, write for FREE TECHNICAL DATA FILES.

Iridite is approved under government and industrial specifications.

Allied Research Products, Inc.

4004-06 EAST MONUMENT STREET • BALTIMORE 5, MARYLAND
BRANCH PLANT: 400 MIDLAND AVENUE • DETROIT 3, MICHIGAN
West Coast Licensee for Process Chemicals: L. H. Butcher Co.
European Agent: Stora Gronberger, Storgatan 10, Stockholm, Sweden
Chemical and Electrochemical Processes, Anodes, Rectifiers, Equipment and Supplies for Metal Finishing

IRIDITE® Chromates | IRILAC® Coatings | ISOBRITE® Brighteners | ARP® Supplies | WAGNER Equipment

valves. Each valve has two in-line ports and a third port perpendicular to them. Operating pressure at all ports is 0 to 3000 psig (0 to 6000 psig on special models). Proof pressure is 4500 psig, and burst pressure is 7500 psig. Ambient and line-fluid operating temperature is from —65 to 160 F (special models up to 300 F). Requires 18 to 29 v dc or 100 to 125 v ac coil. **Marotta Valve Corp, Boonton, NJ.**

CIRCLE 322 ON READER SERVICE CARD

Pushbutton tie-clamp . . .

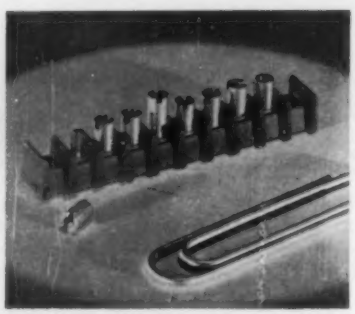
snaps into any 0.250 to 0.265-in.-dia hole, fastening wire tie to chassis or frame. Tie adjusts to 30 sizes from $\frac{1}{8}$ to $1\frac{7}{16}$-in. dia and can be opened and closed without removing pushbutton mounting. Made of high-dielectric polyethylene in red, blue and yellow. Priced at $13.95 per 1000 in quantities from 1000 to 9999. **Richco Plastic Co, 3722 W North Ave, Chicago 47.**

CIRCLE 323 ON READER SERVICE CARD

Size 00 starters, contactors

are suitable for nonreversing, full-voltage starting of $\frac{1}{3}$- to 2-hp squirrel-cage motors. Can be used on either single- or three-phase motors operating on 110 to 600 v, 25 to 60 c. Starters are equipped with melting-alloy, thermal-overload relays. Available as open type or in NEMA Type 1 enclosures in three forms: for separate pushbutton operation; with "hand-off-automatic" selector switch; or with "start-stop" pushbutton. **Clark Controller Co, 1146 E 152nd St, Cleveland 10.**

Circle 324 on Reader Service Card

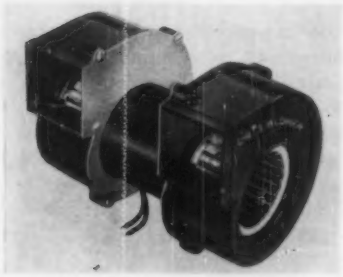


Molded-barrier terminal block . . .

measuring $\frac{7}{16}$ in. wide and $4\frac{1}{8}$ in. long, accommodates up to 21 terminals. Has threaded studs and slotted nuts for rapid

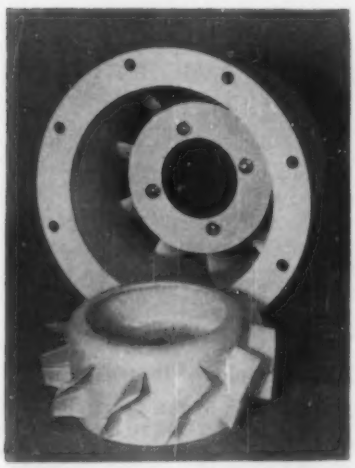
assembly. Hole lug is slipped over stud and slotted nut then is tightened. **Kukla Electric Corp, 633-643 S Fulton Ave, Mt Vernon, NY.**

Circle 325 on Reader Service Card



Dual-outlet blower . . .
has 115-v, 60-c motor (220-v available on special order). Operates in ambient temperatures of −29.2 to 199.4 F and has total free-air delivery of 150 cfm. Rated at 90 cfm at 0.4 in. of water static pressure. Measures 6⅜ in. long x 7¾ in. wide. **Ripley Co Inc, Middletown, Conn.**

Circle 326 on Reader Service Card



Induction-type vane-axial fan
operates on 115 v, 60 c at 3450 rpm. Its 5.65-in. tip dia delivers 250 cfm at a total pressure rise of 1.15 in. water. Slotted blades give boundary layer-control of noise and vibration. **General Dynamics Corp, Groton, Conn.**

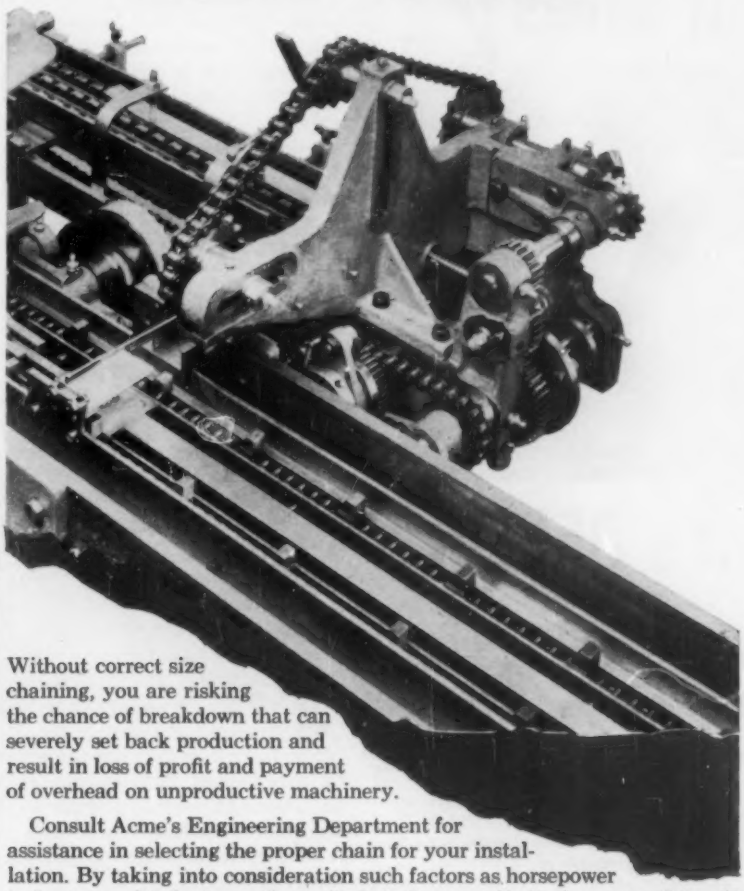
Circle 327 on Reader Service Card

Servomount clamps . . .
firmly holds any standard servomount component in place when three are attached to test or other fixtures. Eliminates need for clamping feet. Have one tapped hole mounting and operating handles of various lengths. Priced at $12.50 each. Delivery in 1 wk. **Angler Industries, Metuchen, NJ.**

Circle 328 on Reader Service Card

DO YOU HAVE THE BEST CHAIN SELECTION

For Efficient Operation of your installation?



Without correct size chaining, you are risking the chance of breakdown that can severely set back production and result in loss of profit and payment of overhead on unproductive machinery.

Consult Acme's Engineering Department for assistance in selecting the proper chain for your installation. By taking into consideration such factors as horsepower to be transmitted, size and speed of shaft, space limitations, etc. this will determine the standard size of chain required to do the job best. This size or any other can be obtained off-the-shelf from your local Industrial Distributor.

Your Industrial Distributor can supply you promptly with Acme Roller Chains in 12 standard sizes from ¼" pitch to 2½" pitch. He has the full cooperation of our Engineering Department. Contact him.

Acme Chain Corporation
HOLYOKE MASSACHUSETTS

Write Dept. 1-R for new ill. 100 page catalog with engineering section.

RELIABLE CHAIN DRIVES FOR ALL INDUSTRIES

ROLLER CHAINS, SPROCKETS, CONVEYOR CHAINS, FLEXIBLE COUPLINGS, ATTACHMENTS. (Special and Standard)

it's DELRIN*

You get metal-like properties in these new, plastic, prevailing-torque lock nuts: excellent strength, rigidity and dimensional stability.

Recommended for light metal assemblies, toys and similar fastening . . . they can save about half the cost of aluminum lock nuts.

Available in #10 and ¼" sizes, the RB&W open end acorn nuts have holding strength of 500-700 lbs in straight tension. Prevailing torque (a measure of its locking) is 8-10 in-lbs for the #10; and 12-15 in-lbs for the ¼". The nut forms its own thread. Pigmented gray is standard; other colors available in production quantities. Reusable. Send for samples.

Ask about other sizes and styles . . . and other parts custom molded from Delrin or other thermoplastics in production lots.

Write Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

*Du Pont trademark

RB&W
116th year

DESIGN LITERATURE

Creative Engineering Design

HAROLD R BUHL, associate professor of engineering, Iowa State Univ. Iowa State University Press, Ames Iowa. 7 x 9, 195 pp. $3.95.

Recent studies at the University of Chicago indicate that creativity and a sense of humor are very closely linked. If this is so, Professor Buhl has the right idea because he has used a number of cartoons, and, practically speaking, cartoons only, to illustrate this text. It also has an unusual format, with the outer third of each page devoted to footnotes, the cartoons, and space for the reader's notes and comments.

Essentially he is aiming at executives who want to stimulate and encourage an understanding of the creative process and to inspire creative effort among personnel. The book, however, will also be useful to engineers seeking ways to improve their creative output. Professor Buhl admits that some individuals have much more innate ability than others in this direction, but believes that awareness of the obstacles to creativity and application of creative problem-solving in everyday work will result in improvement and fuller use of whatever innate ability the individual may have. Obstacles to creativity are sometimes psychological factors within the person himself, or they may lie within his environment, Buhl explains, or in his habitual methods of perception and thought. Something can be done to remove these obstacles by following proper procedures.

Along with discussions of the specific phases of engineering-problem solution, which include discussions of the traits of the creative engineer and the creative supervisor, the book provides simple problems, useful references and pertinent quotes. It received the 1960 award of the University Press as the most significant new book by a faculty member. —EJT

Tactual Coding of Cylindrical Knobs

PB 161483. J V Bradley. Office of Technical Services, US Dept of Commerce, Washington 25, DC. 8½ x 11, 29 pp. $1.

Tactual coding of knobs by use of bizarre shapes is frequently achieved at the expense of ease of manipulation and precision, which appear, in many cases, to be optimal when knobs are cylindrical. In order to be able to maximize both discriminability and manipulability, certain parameters of cylindrical knobs were investigated as bases for tactual coding. Rim surface, diameter and thickness were all found to be useful for this purpose.

Properties of Alloys at Elevated Temperatures

PEARL, KAPPELT and KING, Bell Aircraft Corp. PE-161761 (WADC Technical Report 59-702 Part I). Office of Technical Services, Dept of Commerce, Washington 25, DC. 8½ x 11, 250 pp. $4.

Properties of metal are lowered by prolonged exposure to heat as well as increased temperatures. In general, increase in temperature causes a greater strength drop. The effect of temperature and time was reported for six materials: AM 355, PH 15-7 Mo, HK31-H24, Udimet 500, Inconel X, and A286. Of the six, the A286 showed some improvement with temperature because it age hardened. Also its properties did not drop off as rapidly with increase in temperature. Program presents high-temperature data for these materials in tension, compression, bearing and shear.

Other Books of Interest

Laboratories in the Classroom

Science Materials Center Inc, Div of Library of Science, 59 Park Ave South, NY 3. 5½ x 8, 96 pp. $1.45.

Essays by 25 authorities discuss the needs—and the means being applied to satisfy them—of American schools in science and mathematical instruction.

Pasteur and Modern Science

Rene Dubos. Doubleday & Co Inc, 575 Madison Ave, NY 22. 4 x 7, 159 pp. 95¢.

A biography published as part of a series for use on the teaching of scientific subjects.

Michelson and the Speed of Light

Bernard Jaffe. Doubleday & Co Inc, 575 Madison Ave, NY 22. 4 x 7, 197 pp. 95¢.

Another biography in the same series mentioned above.

The Universe at Large

Hermann Bondi. Doubleday & Co Inc, 575 Madison Ave, NY 22. 4 x 7, 154 pp. 95¢.

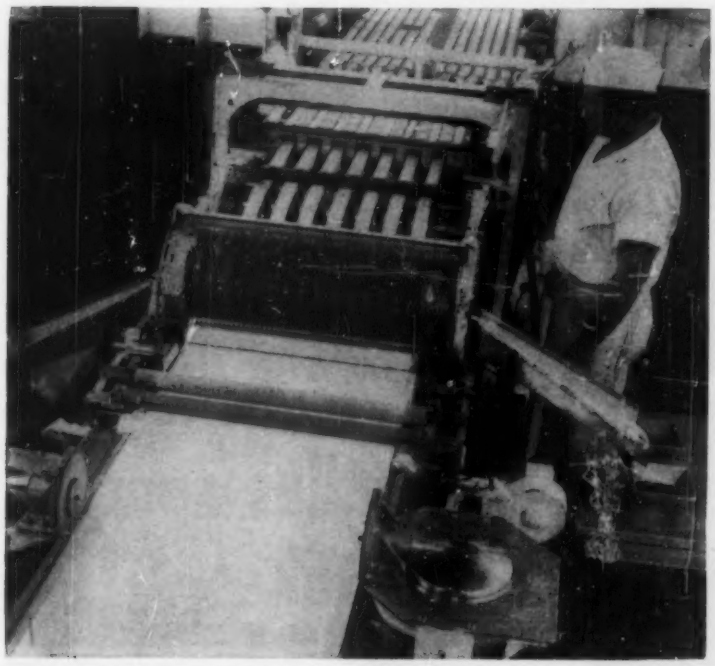
A discussion of cosmology and the steady-state theory of the expanding universe by the proponent of this theory. In laymen's terms.

continued on page 69

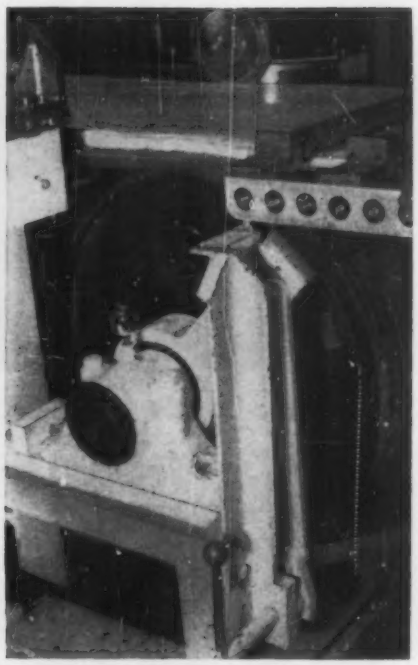
Mars, Inc.
maintains product uniformity

with USS **Lorig-Aligner** Self-Centering Rolls

This mark tells you a product is made of modern, dependable Steel.



Cooled slab of nougat rides the Stainless Steel belt to the cutting machinery where it is slit to candy-bar width and cross-cut to length.



MARS uses USS LORIG-ALIGNER Type III Rolls to center Stainless Steel belt carrying candy slab.

Mars, Inc. produces millions of candy bars a day and USS LORIG-ALIGNER Self-Centering Rolls help maintain uniformity from bar to bar.

At Mars, a steady stream of warm candy pours from the mixers onto a 32" wide x 150' long Stainless Steel belt moving at high speed. At this point, the candy is formed into a continuous slab of nougat that has been accurately sized to a width and thickness. Solidification then takes place as the slab is carried through a refrigerated muffle. As it leaves the delivery end of the muffle and is discharged from the belt, the slab of nougat is slit to candy-bar width and cross-cut to length.

Hour after hour this operation continues, with little variance in size. The answer to such uniform and unerring tracking lies in the USS LORIG-ALIGNER Self-Centering Rolls which carry the belt.

The self-centering action inherent in LORIG-ALIGNER Self-Centering Rolls compels the belt to travel in *exactly* the same path each revolution. Therefore, the slab of candy has no lateral movement because the belt's roll-established center-line does not weave, even though the can bered edges of the belt may show a variation in travel. Such accurate control of belt travel assures increased production and yield, and lowers maintenance costs.

USS LORIG-ALIGNER Self-Centering Rolls eliminate the need for expensive roll-tilting mechanisms and complicated edge-travel sensing devices. There is no belt distortion with LORIG-ALIGNER Rolls because high belt tension is not necessary. USS LORIG-ALIGNER Self-Centering Rolls have many applications, and we will be glad to tell you about them. Just mail the coupon for more information.

USS and "LORIG-ALIGNER" are registered trademarks of United States Steel
"MARS" is a registered trademark of Mars, Inc., Chicago, Ill.

United States Steel
Room 2801, 525 William Penn Place
Pittsburgh 30, Pa.

Please send your booklet, "USS LORIG-ALIGNER Self-Centering Rolls" to:

Name _____

Company _____

Address _____

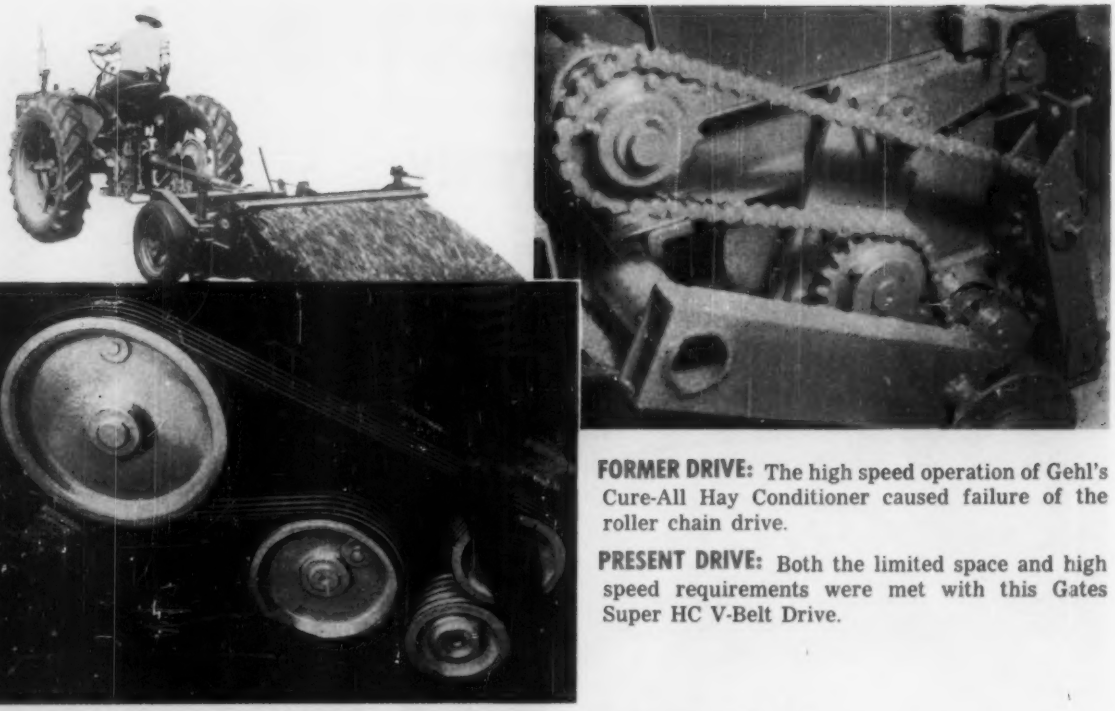
City _____ **State** _____

(Please Print)

USS

United States Steel Corporation — Pittsburgh
American Steel & Wire — Cleveland
National Tube — Pittsburgh
Columbia-Geneva Steel — San Francisco
Tennessee Coal & Iron — Fairfield, Alabama
United States Steel Export Company

United States Steel



FORMER DRIVE: The high speed operation of Gehl's Cure-All Hay Conditioner caused failure of the roller chain drive.

PRESENT DRIVE: Both the limited space and high speed requirements were met with this Gates Super HC V-Belt Drive.

Gehl Brothers Manufacturing Company Finds

Super HC V-Belt Drive handles speeds chain drive couldn't take!

Roller chain drives on Gehl's Cure-All Hay Conditioners **"would not stand up under the speed of operation." Yet conventional V-belts that would fit into the space available could not handle the working load for this outstanding line of forage harvesting equipment.**

The design problem remained a tough one until the introduction of the Gates Super HC High Capacity V-Belt early last year. Then the Gates Field Engineer, working closely with Gehl Engineers designed the new drive shown above.

"The Super HC V-Belt Drive has eliminated need for shear pins and clutches, has increased efficiency, and lowered maintenance costs," is the pleased report from Gehl personnel.

Take advantage of Super HC on your equipment

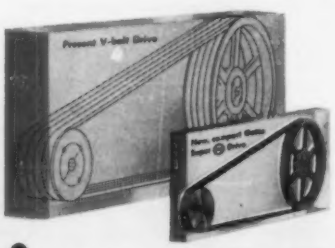
Whenever you have a drive change on a new model or are replacing belts or sheaves, let your Gates Representative show you how Super HC Drives can reduce sheave diameters 30% to 50%, drive space up to 50%, drive weight and cost as much as 20%.

A handbook, "The Modern Way to Design Multiple V-Belt Drives," is yours for the asking. Simply contact your Gates Representative listed in the Yellow Pages.

TPA 505

The Gates Rubber Company, Denver, Colorado
Gates Rubber of Canada Ltd., Brantford, Ontario

Gates *World's Largest Maker of V-Belts*



Gates Super HC V-Belt Drives same hp capacity in smaller "package"

Arithmetic of Computers

Norman A Crowder. Doubleday & Co Inc, 575 Madison Ave, NY 22. 5¾ x 8½, 472 pp. $3.95.

A book for self-teaching the number systems used in electronic computers.

Tables of Higher Functions

Jahnke, Emde, Losch. McGraw-Hill Book Co Inc, 330 W 42nd St, NY 36. 7¼ x 10, 318 pp. $14.

ABSTRACTS FROM THE LITERATURE

Designing Thermoplastic Structural Components

Describes two methods for predicting the load-carrying ability of thermoplastics for any combination of time and temperature.

"Designing Thermoplastic Structural Components," W. D. Harris, Dow Chemical Co; Frederick McGarry, Massachusetts Institute of Technology. SPE Journal, Nov '60. Society of Plastics Engineers Inc, 65 Prospect St, Stamford, Conn.

Recent Developments in Fuel Cells

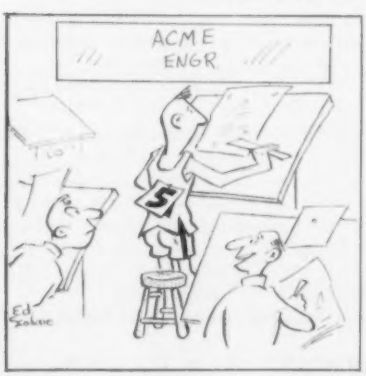
This paper defines fuel cells, describes some of their characteristics, and presents some of the problems which still remain to be solved before the fuel cell can take its proper place as a leading energy-conversion device.

"Recent Developments in Fuel Cells," Dominick A. Sama, Lowell Technological Institute, Lowell, Mass. NEREM Conference, Nov '60.

Tests on Gear Oils

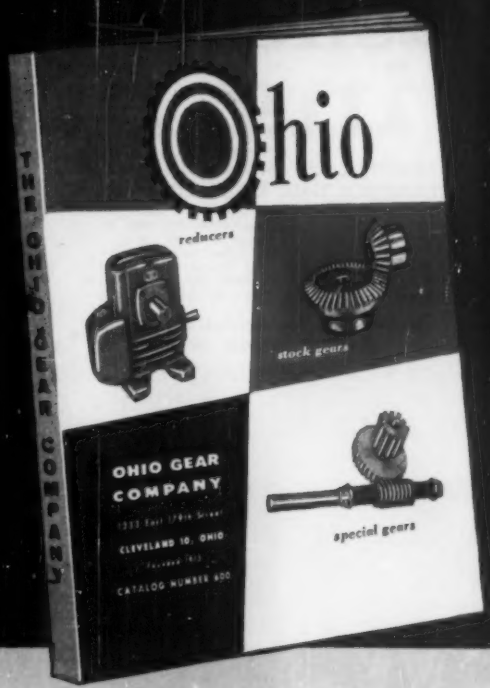
The FZG test is a usual and standardized method in West Germany to evaluate the antiscuffing properties of oils for reduction gears, hypoid gears, automatic transmission gears, etc. The

continued on page 70



"He's been that way since he heard Acme entered the space race!"

Here it is . . . the NEW
OHIO GEAR Catalog
246 pages on gears and speed reducers



The new OHIO catalog—246 pages packed with useful engineering data, sizes, ratings and specifications on one of industry's most complete line of gears and speed reducers.

. . . new convenient size . . . clearly indexed . . . spiral bound to lay flat . . . fully illustrated . . . complete and unabridged.

WRITE FOR YOUR COPY TODAY!
Please use your company letterhead and specify your title or occupation.

CONTENTS:

Speed Reducers
- Reducer Classifications
- Engineering Data
- Installation & Maintenance
- Selection Chart
- Reducers by type and size

Gears
- Stock Gear Lists
- Rules for figuring
- Tooth Data
- Ratings

Sprockets
- Engineering Data & Tables

Ohio
OHIO GEAR CO.
1417 East 179th Street • Cleveland 10, Ohio

another new exclusive
GRC idea

smart
exclusive
new

GRC
washer base
wing nuts

• RUST-PROOF, CORROSION RESISTANT ZINC ALLOY
• CUT ASSEMBLY TIME • CUT COSTS

Integral wide diameter washer base eliminates need for separate washer. You save assembly time and labor. Lower your inventory costs as well! These patented GRC recessed-wingnuts are highly suitable for all wing nut applications; especially desirable for use with oversize bolt holes, adjusting slots, soft surfaces. Hold better because of greater seating area. 14 thread sizes—#6 thru ⅜". In addition, GRC has the most complete stock of standard and special wing nuts and cap nuts in the widest range of styles and sizes.

Write today for samples, prices and detailed fastener catalog.

GRIES REPRODUCER CORP.

World's Foremost Producer of Small Die Castings

159 Beechwood Ave., New Rochelle, N. Y. NEw Rochelle 3-8600

25 years of progress in tiny parts

CIRCLE 204 ON READER SERVICE CARD

SYNCHRO NEWS!

VERNITRON 3-MINUTE CONTROL SYNCHROS DELIVERED ON REGULAR PRODUCTION BASIS

60 & 400 CYCLE

ALL SIZES—11 through 23

ALL TYPES — Transformers, Transmitters, Differential Transmitters—Thru-Bore and Standard

ALL ENGINEERED & MANUFACTURED TO:
MIL-S-2335 MIL-S-16892 FXS-1066
MIL-S-12472 MIL-S-20708A

ALL AVAILABLE WITH MAXIMUM ELECTRICAL ERROR OF ±3 MINUTES! A major break-through, made possible by VERNITRON specialization in precision synchro component design and manufacture.

WRITE, WIRE, PHONE NOW for complete price, delivery and specification data; ask for new Vernitron Catalog

VERNITRON CORPORATION

THE QUALITY NAME IN PRECISION SERVO COMPONENTS

119 Old Country Rd., Carle Place, N. Y. Pioneer 1-4130 TWX: G-CY-NY-1147
West Coast Plant: 1742 S. Crenshaw Blvd., Torrance, Cal.—FAirfax 8-2504 • TWX: TNC-4301

paper gives a brief survey of the test apparatus, the test gears, and the test procedure. It describes also the criteria of failure and the evaluation of the results, taking into account not only the load-carrying capacity but also the wear performance of an oil. The repeatability and the scattering range is discussed with respect to the test conditions.

"Scuffing Tests on Gear Oils in the FZG Apparatus," Niemann, Rettig, Lechner, Technische Hochschule Muchen. American Society of Lubrication Engineers Paper No. 60 LC-3, 5 N Wabash Ave, Chicago 2.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

FILTER COMPONENTS & ASSEMBLIES—Catalog, 32 pp. Details performance characteristics of filter media and elements; provides specifications and dimensional drawings of eight assemblies. Formulas and curves help determine envelope size, pressure loss and capacity. Screen Products Inc, Passaic Ave, Caldwell, NJ.

Circle 350 on Reader Service Card

SNAP-ACTION SWITCHES—Catalog 1110, 32 pp. Discusses currents, contacts and loads; defines switch terms; and offers performance data and dimensional drawings of close to 50 sensitive, miniature, subminiature, heavy-duty and enclosed limit switches and actuators. Licon Div, Illinois Tool Works, 6606 W Dakin, Chicago 34.

Circle 351 on Reader Service Card

GROOVE PINS & DRIVE STUDS—Catalog, 12 pp. Traces drilled-hole tolerances, shear strength, max torque, insertion forces and hp transmitted. Compares locking effectiveness of groove pins with standard taper pins and tabulates drive stud specifications. Groov-Pin Corp, 1125 Hendricks Causeway, Ridgefield, NJ.

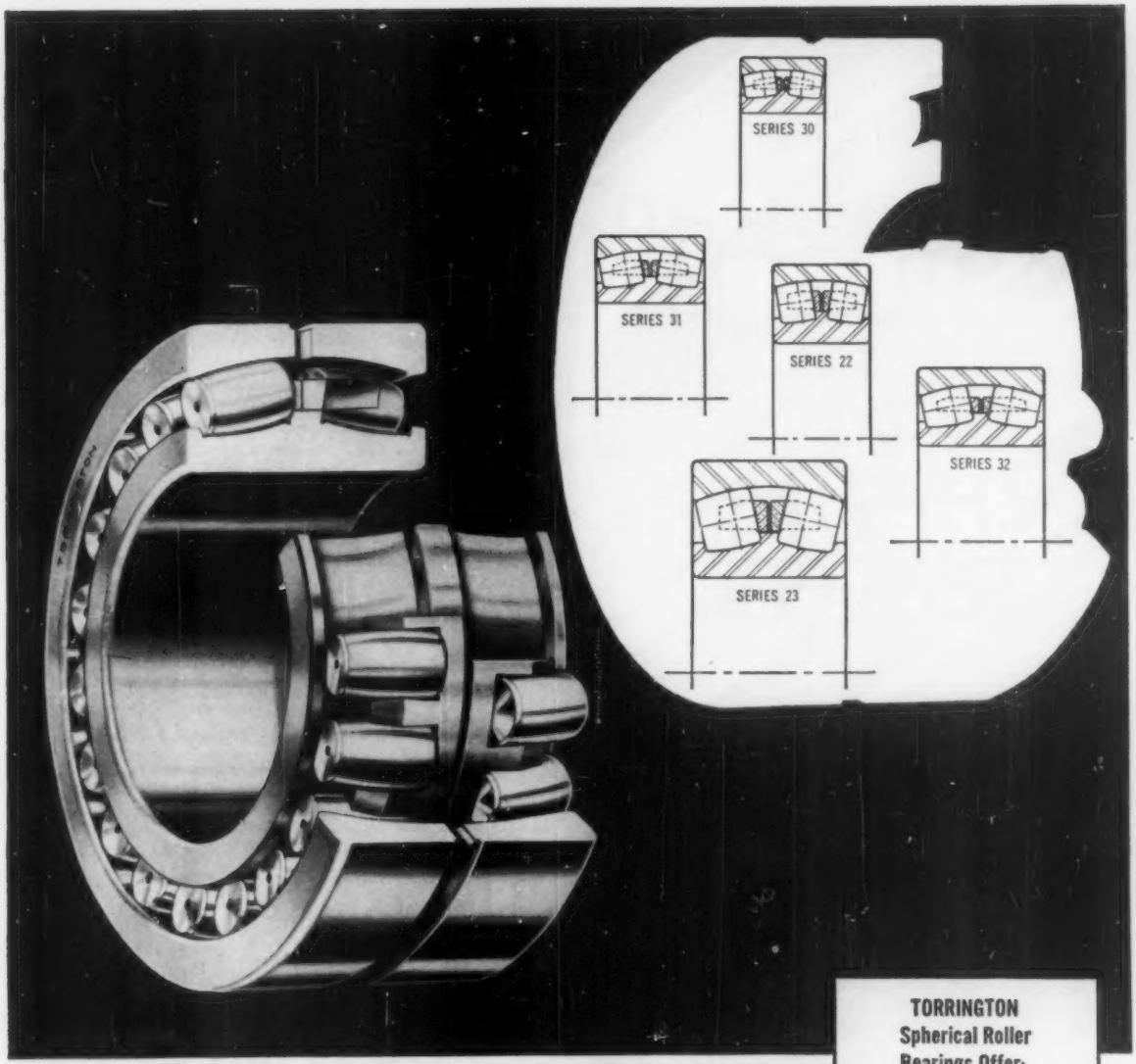
Circle 352 on Reader Service Card

FIBERGLASS YARN—Brochure FTX-5A, 12 pp. Describes fiberglass manufacture from raw materials to eight types of yarn and textile fiber. Compares properties of fiberglass with asbestos, cotton, nylon and Dacron. Johns-Manville, Fiber Glass Div, Textile Glass Dept, 1810 Madison Ave., Toledo I, Ohio.

Circle 353 on Reader Service Card

SLIPPABLE FLUID CLUTCHES—Brochure, 20 pp. Tabulates specifications and

continued on page 73



There's a Torrington Spherical Roller Bearing for your application

Bearings matched *exactly* to the job pay off in better performance, longer life, greater reliability. That's why it pays to specify carefully. And that's why it pays to choose Torrington Spherical Roller Bearings.

Whatever your space limitations or capacity requirements, the five series of Torrington Spherical Roller Bearings provide the right bearing for virtually every industrial application. You can design for straight bore or tapered bore with adapter. You can benefit from extra features such as lubrication groove and oil holes, or selected outside diameters.

Your use of Torrington Spherical Roller Bearings will assure exceptional operation and longer bearing life under the toughest conditions. They're made to Torrington's own uncompromising standards—the highest in the field of anti-friction engineering—by the manufacturer of every basic type of anti-friction bearing.

TORRINGTON Spherical Roller Bearings Offer:

- conformity of rollers to raceways
- integral center guide flange for stability
- positive roller guidance
- land-riding bronze cages
- maximum radial and thrust capacity
- controlled internal clearance
- electronically selected rollers
- inherent self-alignment
- even load distribution
- long, dependable service life

Send for new Torrington Spherical Roller Bearing Catalog #258

progress through precision **TORRINGTON BEARINGS**

THE TORRINGTON COMPANY South Bend 21, Indiana • Torrington, Conn.

"Special" WEBBING at Standard PRICES

Buy from America's biggest selection of widths, weights, materials, styles, solid colors and patterns . . . all at low STANDARD PRICES.

No matter what product you make that requires webbing, we'll wager we have the exact width, weight, style and color you require. And . . . we can probably sell it from our STANDARD price list, too . . . not a SPECIAL price list, as happens with most manufacturers. We are America's oldest manufacturer of webbings. Huge line includes rayon, nylon, dacron, dynel, cotton, jute, combed peeler mercerized and high tensile webbings. Let us send you the facts!

Send for LITERATURE, SAMPLES, and PRICES

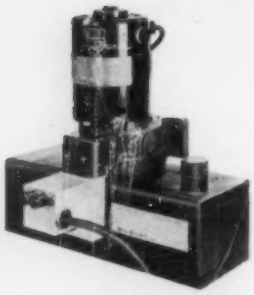
If possible, send us sample to match. Send for Free Folder.

BUFFALO WEAVING AND BELTING CO., INC.

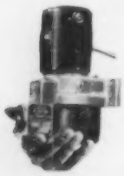
206 CHANDLER STREET BUFFALO 7, NEW YORK

We also manufacture a complete line of WOVEN COTTON CONVEYOR BELTING and PURE SHEET RUBBER.

A complete OIL-DYNE hydraulic unit could fit on this page — with room to spare!



If you still believe that hydraulic units must be big and bulky, you just haven't seen Oil-Dyne's miniature power package! And if you think the motor or pump must run constantly, you haven't heard that an Oil-Dyne motor and pump run ONLY while the cylinder piston is in motion. Perhaps, too, you didn't know that Oil-Dyne has eliminated all the complex external valving for directional control . . . and that when you shut off an Oil-Dyne reversible pump, the piston is automatically locked in position, and stays there indefinitely. Just to make sure you're aware of what's happened in hydraulics since Oil-Dyne pioneered miniaturization, you ought to write for our Catalog 21-E.



PIONEERING MINIATURIZED HYDRAULIC ACTUATION

OIL-DYNE INC.

2115Z West Marquette Road • Chicago 36, Ill.

PUMPS • CYLINDERS • VALVES

PRESSURE SWITCHES • ACCESSORIES

CIRCLE 205 ON READER SERVICE CARD

USE THE READERS' SERVICE CARD

for:

additional product information

copies of catalogs & bulletins

shows dimensional drawings and speed curves of six self-contained, clutch and speed-control models. Hydraulics Inc, 1831 S Boulevard, Parsons, Kan.

Circle 354 on Reader Service Card

SPEED MEASUREMENT—Bulletin 1000, 4 pp. Explains operation of self-generating, 3-phase electric tachometer generators and indicators. Chart determines rpm range for specific drive ratio from 35 to 35,000 rpm. Meriam Instrument Co, 10920 Madison Ave, Cleveland 2.

Circle 355 on Reader Service Card

FANS & BLOWERS—Handbook, approximately 147 pp. Contains typical motor-performance curves and standard flange drawings of eight blower series. Selection charts cover performance from 0 to 20 in. of water static pressure and airflows from 0 to 2200 cfm. Dean & Benson Research Div, Benson Mfg Co, 1811 Agnes, Kansas City 27, Mo.

Circle 356 on Reader Service Card

SILICONE COATINGS FOR PAPER—Booklet CDS-270 16 pp. Describes materials' applications, chemistry and release properties. More than 20 photographs, curves and charts give adhesion, resiliency and tensile-strength data. Silicone Products Dept, General Electric Co, Waterford, NY.

Circle 357 on Reader Service Card

PLASTIC KNOBS—Catalog 8, 12 pp. Illustrates and gives specifications for more than 110 molded knobs for mechanical, electrical and electronic use, appliance feet, instrument cases and multipurpose handles. Harry Davies Molding Co, 1428 N Wells St, Chicago 10.

Circle 358 on Reader Service Card

BRAZING TECHNIQUES—Pamphlet, 4 pp. Contains 12 illustrated case studies of how brazing has solved problems in joining both similar and dissimilar metals. Handy & Harman, 82 Fulton St, New York 38.

Circle 359 on Reader Service Card

SEMICONDUCTOR STRAIN GAGES—Bulletin K-101, 4 pp. Describes and tabulates characteristics of large output gages. Explains gage factors. Kulite-Bytrex Corp, 50 Hunt St, Newton 58, Mass.

Circle 360 on Reader Service Card

ELECTRODE GLANDS—Catalog 960, 8 pp. Covers dimensions, electrical ratings and prices of ceramic and all-Teflon insulated glands for pressure-sealing electrical leads. Pictures standard and special models. Conax Corp, 2300 Walden Ave, Buffalo 25.

Circle 361 on Reader Service Card

GRAPHITE & CARBON FELTS—Bulletin 104, 2 pp. Discusses uses for nonwoven forms of flexible graphite and carbon. Tabulates permeability, resistance, density, strength, gage and weight at room temperature. National Carbon Co, 270 Park Ave, New York 17.

Circle 362 on Reader Service Card

LINE STRAINERS—Bulletin J-LS, 4 pp. Contains performance tips, mesh-selection guide and specifications of 16 steam and liquid strainers. Includes dimensions, particle-retention capabilities and ratios of screen open area to inside pipe area. OPW-Jordan Corp, 6013 Wiehe Rd, Cincinnati 13.

Circle 363 on Reader Service Card

SERVOAMPLIFIERS—Catalog S-1169, 16 pp. Presents specifications of push-pull saturable transformers and all-magnetic, transistor magnetic, transistor servo and miniature amplifiers. Includes application data and schematics on closed-loop 1- and 2-speed systems and signal-input requirements for servoamplifier-motor combinations. Magnetic Amplifiers Div, Siegler Corp, 632 Tinton Ave, New York 55.

Circle 364 on Reader Service Card

CONTROL VALVES—Catalog J170-1, 8 pp. Gives applications, operating characteristics and pressure and temperature limitations of sliding-gate, diaphragm control valves. Tabulates recommended capacities for saturated steam; water and other liquids; and air and other gases. OPW-Jordan Corp, 6013 Wiehe Rd, Cincinnati 13.

Circle 365 on Reader Service Card

COATED INSULATION MATERIALS—Brochure, 6 pp. Describes Class A coated constructions for 221 F applications, including varnish-coated cotton cloths, silks, canvas and papers. Lists types, colors, thicknesses, conformability, and electric and tensile strengths. Irvington Div, Minnesota Mining & Mfg Co, 900 Bush Ave, St Paul 6.

Circle 366 on Reader Service Card

ELECTRICALLY AND AIR-OPERATED C-CLAMPS—Bulletin 91029, 4 pp. Contains dimensional drawings and specifications of average- and heavy-duty series. Airmatic Valve Inc, 7313 Associate Ave, Cleveland 9.

Circle 367 on Reader Service Card

MICROMINIATURE RELAY—Bulletin, 1 p. Lists specifications and applications, and includes schematics. Filter Inc, Port Washington, NY.

Circle 368 on Reader Service Card

FILTER REGULATOR—Bulletin 1111-A, 2 pp. Contains performance curve, specifications, applications and cutaway drawing of 250 psi inlet-pressure regulator. Rockwell Mfg Co, Meter & Valve Div, 400 N Lexington Ave, Pittsburgh 8.

Circle 369 on Reader Service Card

EPOXY ADHESIVES—Data sheet, 2 pp. Describes and gives curing times of six types. Lists resin mixes and properties of cured resin. Isochem Resins Co, 221 Oak St, Providence 9, RI.

Circle 370 on Reader Service Card

INSPECTION LIGHTS—Bulletin, 4 pp. Describes and illustrates 12 types, including prefocused and adjustable-focus lights, and lights combined with magnifying lenses or rotatable mirrors. Also lists electrical characteristics and dimensions of 14 miniature lamps. Welch Allyn Inc, 172 Jordan Rd, Skaneateles Falls, NY.

Circle 371 on Reader Service Card

FOR MORE CATALOGS AND BULLETINS

. . . 1600 of 'em—see your copy of Product Engineering's Mid-Sep 1960 Design Digest. There you will find helpful design literature, classified under 10 different headings, from important manufacturers and supplies of components materials, power and control systems, manufacturing processes.

REPRINTS

Reprints currently available without charge are listed on the Reader Service Card bound in this issue. Single copy free; quantity prices on request.

The following special reports are available as long as the supply lasts, from Reader Service Dept., Product Engineering, 330 W 42nd St, New York 36. Please enclose remittance with order we pay postage.

R77—The New Mathematics $2
Combined reprint of 18 articles with coverage in depth on the latest math tools of systems engineering, 64 p.

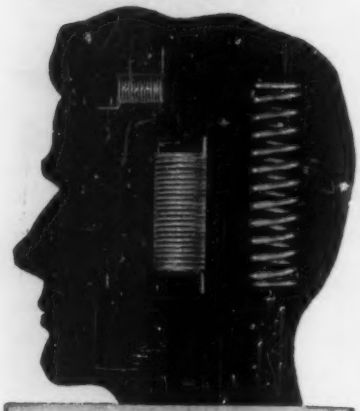
R48—Reinforced Plastic Parts $2
Combined reprints of 11 articles giving design data on the seven processes for commercial parts, 64 p.

R69—Human Engineering $1.50
Series of 14 articles with design data on man-machine problems and human dimensions; plus bibliography, 44 p.

R76—Creativity $1
Combined reprint of 10 articles on the facts behind the fad. 32 p.

continued on page 75

SPRINGS ON YOUR MIND?



• Your next thought should be of the Spring Engineers at John Chatillon & Sons. Send them your blueprints and specifications for study and recommendation.

• With more than 120 years of experience and knowledge at their command, they can provide you with the exact spring you require—on time, at competitive prices.

• Chatillon has the trust of the largest users of springs in the world because of the Chatillon reputation for filling orders that others would consider impossible.

• Next time, benefit by the thorough knowledge of Chatillon Spring Engineers. They'll be glad to help you. Send your blueprints to: Department D-2.

JOHN CHATILLON & SONS

SPRING DIVISION
48 FRANKLIN ST., N. Y. 13, N. Y.

Manufacturers of Precision Springs and Force Measuring Instruments Since 1835.

Index of PRODUCTS ADVERTISED

In This Issue

After reading the advertisements classified below . . . MORE DETAILED INFORMATION about these products can be obtained by using the READER SERVICE CARD.

A

Actuators
Mechanical 22
Aluminum Coated Sheet & Strip (see Steel, Coated)

B

Bearings
Ball 58
Roller 58, 71
Belts, V 68
Bushings 75
Bushings, Strain Relief 75

C

Chains
Conveyor 65
Roller 65
Chemical Treatments 64
Coatings 64
Conveyor Belts 72

D

Decalcomanias 75
Die Castings 70
Drives
Mechanical 68

E

Engines 24

F

Fabrics 72
Fastening Methods 66
Felt 75
Fibre Glass 76
Film, Plastic 14

G

Gears 63, 69
Graphic Charts 74

H

Hydraulic Fluids 10-11

M

Motors, A-C
Fractional ..... 4th Cover
Integral ..... 4th Cover, 5-7
Sub-Fractional 26
Motors, D-C
Fractional ..... 4th Cover
Integral ..... 4th Cover, 5-7
Sub-Fractional 26

N

Name Plates 75
Nuts 66, 70

P

Power Packs
Hydraulic 72
Pumps
Liquid ..... 2nd Cover

R

Rolls 67

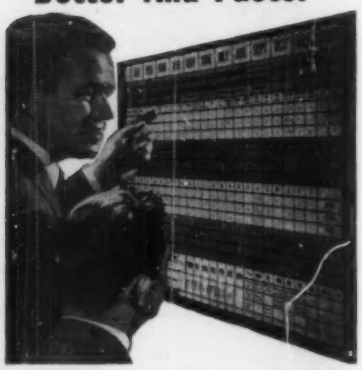
S

Seals ..... 3rd Cover
Servomechanism Components 70
Speed Increasers & Reducers 69
Springs 74
Sprockets 65, 69
Steel
Coated 2
Stainless 67

W

Wire Cloth 23

How To Get Things Done Better And Faster



BOARDMASTER VISUAL CONTROL

☆ Gives Graphic Picture—Saves Time, Saves Money, Prevents Errors
☆ Simple to operate—Type or Write on Cards, Snap in Grooves
☆ Ideal for Production, Traffic, Inventory Scheduling, Sales, Etc.
☆ Made of Metal. Compact and Attractive. Over 500,000 in Use

Full price $49.50 with cards

FREE 24-PAGE BOOKLET NO. DE-30 Without Obligation

Write for Your Copy Today

GRAPHIC SYSTEMS
YANCEYVILLE, NORTH CAROLINA
CIRCLE 206 ON READER SERVICE CARD

EMPLOYMENT OPPORTUNITIES

DISPLAYED RATE

The advertising rate is $37.00 per inch for all advertising appearing on other than contract basis. Frequency rates quoted on request.

UNDISPLAYED RATE

$2.10 per line, minimum 3 lines. Position Wanted ads in this style ½ the above rate. To figure advanced payment count 5 average words to a line.

DESIGN STYLIST

Position requires experience in styling product designs. Preferably in office furniture and equipment field. Well established company in Ohio. Send detailed resume and salary requirements to

P-5718, Product Engineering
520 N. Michigan Ave., Chicago 11, Ill.

***When Answering* BOX NUMBERS . . .**

to expedite the handling of your correspondence and avoid confusion, please do not address a single reply to more than one individual box number. Be sure to address separate replies for each advertisement.

REPRINTS .....continued

R66—The European Engineer Talks $1
The challenge to American proficiency in design from interviews with technical directors in six countries, 24 p.

R16—Plate Cam Design $1
Series of 7 articles with complete design data; curve blending and profile synthesis to reduce inertia, 48 p.

R65—Reading, Writing, Reporting $1
Combined reprint of: 5 steps to faster reading: 8 steps to better writing: 7 steps to better reporting, 24 p.

R46—Manual of Reliability 50¢
How to design for reliability, human factors, statistical tools; implementing the program, 32 p.

R78—Ball Bearings 50¢
Performance of 50 commercial and precision types tabulated and compared 16 p.

R41—Design by Digital Computers 50¢
How to choose and operate desk-size problem solvers, 12 p.

R22—Engineering Organization 25¢
Study of 50 companies shows changes in large and small companies, 24 p.

R21—Engineer's Bookshelf 25¢
Annotated bibliography of technical books for the design engineer, 24 p.

R75—Radiant Cooling 25¢
Design techniques and new emissivity data.

R74—Right-angle Gears 25¢
Detailed guide to all 16 available types.

R73—Digital Readouts 25¢
How they work; how to choose one.

R71—How to Design Nomographs 25¢
Simple step-by-step guide to best method.

R68—Encapsulating Systems 25¢
Comparison and selection of basic systems.

R67—Heat Protectors for Motors 25¢
Response and accuracy of inherent types.

R62—High-speed Photography 25¢
How it can solve design problems.

R53—Significance of WK² 25¢
Selecting Motors for high inertia loads.

"This model has a small gasoline auxiliary motor in case of a power failure."

FREE—and Important!

Handy Check Chart clarifies selection of proper types

JUST PUBLISHED!
Meyercord Directory to QUALITY TRANSFER NAMEPLATES for every surface and condition

Important Facts for your Design and Production Departments

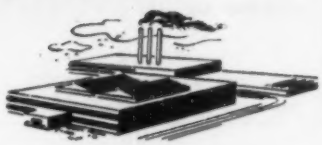
Meyercord produces many different types of Decal Transfers to satisfy the requirements of a wide variety of surfaces and conditions. Available now are Meyercord types that resist abrasion . . . resist weathering . . . and a full selection of heat resistant decals. Some types perform dual functions. It is important to you to know the characteristics of each of these *Performance Rated* transfers. To provide this information in condensed and useful form, Meyercord now offers a new brochure covering the entire subject. It's yours upon request.

Write today . . . on company letterhead, please

the MEYERCORD co. Dept. X-318, 5323 W Lake Street, Chicago 44, Ill.

CIRCLE 207 ON READER SERVICE CARD

Whats NEW in INDUSTRIAL* FELT?



NOW! Synthetic Fiber Felts and Wool Felts designed for exacting, special applications!
NOW! Available CUT to meet your specifications!
NOW! Large diversified inventory insures prompt delivery!

*Available in all weights, widths, colors, etc. and made to S.A.E. and Federal Gov't. Specifications.

FREE
Folder of samples and applications of Industrial Felt. Write for Booklet K-4.

CONTINENTAL FELT COMPANY
22-26 WEST 15th STREET NEW YORK 11, N. Y.

CIRCLE 208 ON READER SERVICE CARD

Heyco Nylon BUSHINGS

STRAIN RELIEFS
The insulating bushing that anchors a cord set to an electrically operated machine or appliance.

JUNCTION-TERMINAL BUSHINGS
Eliminate "pig-tails"—Miniature size. Snap-in assembly, color or number coded. Can be used as plug-in receptacle. Simple quick disconnect.

ACCORDIAN TYPE
Fit curved surfaces
Nylon bushing — brass tab

HEYCO NYLON Snap Bushings

10 Sizes for holes from ⅜" to 1⅜" dia.—various inside diameters. Snap locks into panels up to ½" thick.

SA UL

FREE SAMPLES! BUSHINGS OF YOUR CHOICE

HEYMAN MANUFACTURING COMPANY
KENILWORTH 2, NEW JERSEY

CIRCLE 75 ON READER SERVICE CARD

MOLDED FIBER GLASS

✓ cuts tooling time 50%
✓ cuts tooling costs 80%
✓ cuts weights up to 40%

Aircraft luggage container

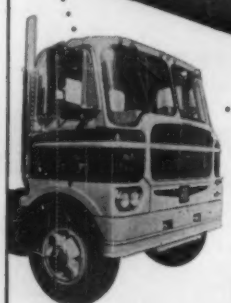
Delivery scooter

MOLDED FIBER GLASS products are strong, impact-resistant, lightweight, rust-resistant, corrosion-resistant, dielectric, beautiful . . . and economical!

The Molded Fiber Glass Body Company specializes in the matched-metal-die molding of large parts for the transportation and agricultural industries.

Write today for literature and detailed information on custom molding your products of MOLDED FIBER GLASS . . . or send drawings.

Agricultural spray tank



Truck cab

Molded Fiber Glass Body Company

GREATEST NAME IN REINFORCED PLASTICS — MOLDED FIBER GLASS

4623 Benefit Avenue, Ashtabula, Ohio

INDEX TO ADVERTISERS

This index is published as a convenience to the readers. Every care is taken to make it accurate but PRODUCT ENGINEERING assumes no responsibilities for errors or omissions

A

Acme Chain Corp. 65
Allied Research Products, Inc..... 64
Armco Steel Corp. 2

B

Beaver Precision Products, Inc..... 22
Buffalo Weaving & Belting Co., Inc... 72

C

Chatillon & Sons, John..... 74
Continental Felt Co., Inc..... 75

D

du Pont de Nemours & Co., (Inc.), E. I., Photo Products Dept..... 14

E

Emerson Electric Mfg. Co.....4th Cover

F

Franklin Electric Co., Inc..... 5-7

G

Gates Rubber Co. 68
Gleason Works 63
Globe Industries, Inc. 26
Graphic Systems 74
Gries Reproducer Corp..... 70

H

Heyman Mfg. Co. 75

L

Link-Belt Co. 58

M

Meyercord Co., Name Plate Div..... 75
Molded Fiber Glass Body Co..... 76
Monsanto Chemical Co., Organic Chemicals Div. 10-11

N

National Seal Div., Federal-Mogul-Bower Bearings, Inc.....3rd Cover
Newark Wire Cloth Co..... 23

O

Ohio Gear Co. 69
Oil-Dyne, Inc. 72

R

Russell, Burdsall & Ward Bolt & Nut Co. 66

T

Torrington Co., Bearing Div..... 71

U

United States Steel Corp..... 67

V

Vernitron Corp. 70

W

West Bend Aluminum Co..... 24
Worthington Corp. .....2nd Cover

LLOYD R. LAWRENCE *advertising sales manager*

P. F. PRITCHARD *manager, market development*

THOMAS R. COASH *circulation*

RUSSELL T. DOUGLAS *business manager*

ADVERTISING SALES STAFF

ATLANTA 9 . . . Ray K. Burnet, 1375 Peachtree St, N.E., Trinity 5-0523

BOSTON 16 . . . M. A. Williamson, Jr., McGraw-Hill Bldg, Copley Square, Congress 2-1160

CHICAGO 11 . . . Mid-Western Adv Sales Manager, A. E. Meanor; R. W. Bruley, L. Anderson, 520 N Michigan Ave, Mohawk 4-5800

CLEVELAND 13 . . . A. F. Tischer, 1164 Illuminating Bldg, 55 Public Sq, Superior 1-7000

DALLAS 1 . . . John Grant, 901 Vaughn Bldg, 1712 Commerce St, Riverside 7-5117

DENVER 2 . . . John W. Patten, Tower Bldg, 1700 Broadway, Alpine 5-2981

DETROIT 26 . . . P. B. Robinson, 856 Penobscot Bldg, Woodward 2-1793

HOUSTON 25 . . . Gene Holland, W-724 Prudential Bldg, Jackson 6-1281

LOS ANGELES 17 . . . Robert Obenour, 1125 West 6th St, Huntley 2-5450

NEW YORK 36 . . . B. K. Adams, F. J. McKinley, 500 Fifth Ave, Oxford 5-5959

PHILADELPHIA 3 . . . John B. Lewis, H. M. Nicholson, 6 Penn Center Plaza, Locust 8-4330

PITTSBURGH 22 . . . C. F. Leveroni, 4 Gateway Center, Express 1-1314

PORTLAND 4, ORE. . . . Scott Hubbard, 445 Pacific Bldg, Capital 3-5118

ST LOUIS 8 . . . R. W. Bruley, 3615 Olive St, Continental Bldg, Jefferson 5-4867

SAN FRANCISCO 4 . . . W. C. Woolston, 68 Post St, Douglas 2-4600.

SUBSCRIPTIONS. Send subscription correspondence and change of address to Fulfillment Manager, PRODUCT ENGINEERING, 330 W 42nd St, New York 36, NY. Subscribers should notify Fulfillment Manager promptly of any change of address including postal zone number, if any. If possible, enclose an address label from a recent issue of the magazine. Since copies are addressed one to two issues in advance, please allow one month for change of address to become effective. Subscriptions are solicited only from executives, engineers and consultants engaged in the design of machinery and other engineered products. Position and company connection must be indicated on subscription orders.

OFFICERS OF THE PUBLICATIONS DIVISION: Nelson L. Bond, President; Shelton Fisher, Wallace F. Traendly, Senior Vice Presidents; John R. Callaham, Vice President and Editorial Director; Joseph H. Allen, Vice President and Director of Advertising Sales; A. R. Venesian, Vice President and Circulation Coordinator. OFFICERS OF THE CORPORATION: Donald C. McGraw, President; Joseph A. Gerardi, Hugh J. Kelly, Harry L. Waddell, Executive Vice Presidents; L. Keith Goodrich, Vice President and Treasurer; John J. Cooke, Secretary.

CLASSIFIED ADVERTISING
F. J. Eberle, Business Mgr.

EMPLOYMENT OPPORTUNITIES 74

PERSONAL READER SERVICE

USE ATTACHED CARDS FOR PERSONAL COPIES OF ADDITIONAL PRODUCT DESIGN DATA

. . . Data on Materials and Components
. . . Free Article Reprints
. . . New Catalogs and Bulletins
. . . Brochures on Advertised Products
. . . Personal Suscriptions to PRODUCT ENGINEERING

Valuable new data on product design engineering — readily available to you — FREE.

Just circle the numbers on the request cards that are identical with the numbers printed under each Advertisement, New Product and Bulletin throughout this issue.

Reprint numbers are prefaced with the letter "P". *One free reprint* is available for each article offered.

Issue of December 26, 1960
PRODUCT ENGINEERING
Card expires February 24, 1961

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

Postage Will Be Paid By Reader Service Department

PRODUCT ENGINEERING
330 WEST 42nd STREET
NEW YORK 36, N. Y.

22 FL

USE THIS CARD

to be sure to get your personal subscription to PRODUCT ENGINEERING sent each week to your home or office.

Now only $3 per year (U.S.A.)

Issue of December 26, 1960
PRODUCT ENGINEERING

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

Postage Will Be Paid By Reader Service Department

PRODUCT ENGINEERING
330 WEST 42nd STREET
NEW YORK 36, N. Y.

22 FL

ADD TO YOUR DESIGN REFERENCE FILE FROM

EDITORIAL REPRINTS AVAILABLE

(Single reprints free, additional copies 6 for $1)

P51—PNEUMATICS SIMULATES ELECTRONICS
Dimensional analysis of all units needed in control service.

P52—SELECTING SOLENOIDS
A guide to ac or dc, and linear or rotary types.

P53—LIGHT-DUTY BELT DRIVES
Performance compared for all five basic types.

P54—EPICYCLIC GEAR SYSTEMS
Modified equations give volume, power capacity, ratios, and stresses.

P56—TAPERED CANTILEVER BEAMS
How to calculate stresses and deflections for five sections.

P58—STRONG ALUMINUM ALLOYS
How the new X2020 stacks up with other high-strength alloys.

P59—THE RESPONSE EQUATION
Some graphical tricks that eliminate tedious slide rule work.

P60—ACCELEROMETER
Evaluation of all types suitable for control applications.

P61—DIMENSIONAL STABILITY IN PRECISE PARTS
How properties change under stress and heat.

P62—FRICTION COEFFICIENTS
Complete table; how to adapt values to actual service.

P64—BENDING GAGE
New strain gage system measures from one side of section.

P65—HELICAL GEARS
How to change pitch diameter by varying pitch angle.

P66—SLIDERULES
Get more from your sliderule shortcuts to solution of complex problems to greater accuracy.

P67—NEW DRAWING SYSTEM
Permits direct projection between any two orthographic views.

P68—COPPER CASTING ALLOYS
Properties of 12 high-conductivity alloys charted for precise selection.

P69—FLUID FILTERS
Comprehensive report evaluates all types of filtering method and materials for hydraulic and pneumatic systems.

P70—BOLTING TORQUE FOR PLATED BOLTS
Effect of plating on bolt, nut or washer on bolt tension.

P71—STAINLESS HONEYCOMB PANELS
Basics of design, materials to use, practical details of construction.

P72—SAMPLING THEORY
How representative is that sample? Here's the mathematical proof.

P73—CLUTCHES, BRAKES FOR CONTROL
Data on three major types, 10 basic designs and 12 applications.

P74—ALL TANGE
Sixteen of Editor Tangerman's editorials, starting with "The Age of Goofing Off."

P75—DRIVE ACCELERATION TIME
Simple tests help in selecting motors for special duty cycles.

(please print or type) *If this is change of address, check box* ☐

Name ..... Title .....

Street .....

City ..... Zone ..... State .....

Company ..... Major Product Manufactured .....

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	316	331	346	361	376
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

REPRINTS
P51 P52 P53 P54 P56 P58 P59 P60 P61 P62 P64
P65 P66 P67 P68 P69 P70 P71 P72 P73 P74 P75

*MULTIPLE PRODUCT ADS

Key No.	Specific Product

FRESH NEW DESIGN IDEAS EVERY WEEK!

Have your own personal subscription to PRODUCT ENGINEERING sent each week to your office or home. ACT NOW. Fill out this card today to make sure you won't miss a single issue.

☐ 1 year—NOW $3 U.S. only* ☐ 2 years—NOW $4

*Canada
1 year—$5
2 years—$8

☐ Payment enclosed

☐ Bill me

Name ..... Title .....

Home ☐ .....

Address Office ☐ ..... Dept .....

City ..... Zone ..... State .....

Company Name ..... Product Mfgd .....

NEW CATALOGS AND BULLETINS

RESEARCH AND TEST EQUIPMENT

360—Semiconductor Strain Gages, 4 pp, Kulite-Bytrex Corp.

METALS AND ALLOYS

359—Brazing Techniques, 4 pp, Handy & Harman

NON-METALLIC MATERIALS, FINISHES

353—Fiberglass Yarn, 12 pp, Johns-Manville Fiber Glass Div.

357—Silicone Coatings for Paper, 16 pp, General Electric Co.

366—Coated Insulation Materials, 6 pp, Minnesota Mining & Mfg Co.

370—Epoxy Adhesives, 2 pp, Isochem Resins Co.

FABRICATION PROCESSES AND PRODUCTION

359—Brazing Techniques, 4 pp, Handy & Harman

362—Graphite & Carbon Felts, 2 pp, National Carbon Co.

THIS WEALTH OF VITAL INFORMATION . . .

NEW COMPONENTS

GENERAL ENGINEERING
328—Servomount Clamps

NON-MATALLIC MATERIALS, FINISHES
313—Mass Production Sealing

FABRICATION PROCESSES AND PRODUCTION
313—Mass Production Sealing

POWER TRANSMISSION
303—Five-hp Transmission
307—Index Drive Has Zero Backlash

MECHANICAL PARTS
305—Two-part Sliding Door Track
308—Metallic Static Seal
309—Miniature Bellows

FASTENING AND JOINING
306—Folded Rim Lock Washer
323—Pushbutton Tie-clamp

MOTORS, ENGINES AND CONTROLS
303—Five-hp Transmission
310—Indicator With One Moving Part
312—Chronemetrically-governed Motor
316—Infrared Detector
319—Phase-shifting Transducer

ELECTRICAL, ELECTRONIC COMPONENTS
302—Low-temperature Infrared Heat
304—Wheel on Switch Top
310—Indicator With One Moving Part
315—Solenoid-driven Rotary Switch
316—Infrared Detector
319—Phase-shifting Transducer
320—Solid State Time Delays
321—All-rubber Pushbutton Station
323—Pushbutton Tie-clamp
324—Size 00 Starters, Contactors
325—Molded-barrier Terminal Block
326—Dual-outlet Blower
327—Induction-type Vane-axial Fan

HYDRULIC, PNEUMATIC EQUIPMENT
300—Filter Has Magnet Positioned Downstream
301—Disposable Interception Filter
308—Metallic Static Seal
311—Hydraulic Power Supply
314—Hydraulic, Air Check Valve
317—Coupler Combines O-ring, E-packer Seals
318—Centrifugal Pumps
322—Self-manifolding Valve

POWER TRANSMISSION
354—Slippable Fluid Clutches, 20 pp, Hydraulics Inc.

MECHANICAL PARTS
352—Groove Pins & Drive Studs, 12 pp, Groov-Pin Corp.
358—Plastic Knobs, 12 pp, Harry Davies Molding Co.
367—Electrically and Air-operated C-clamps, 4 pp, Airmatic Valve Inc.

FASTENING AND JOINING
370—Epoxy Adhesives, 2 pp, Isochem Resins Co.

MOTORS, ENGINES AND CONTROLS
355—Speed Measurement, 4 pp, Meriam Instrument Co.

ELECTRICAL, ELECTRONIC COMPONENTS
351—Snap Action Switches, 32 pp, Illinois Tool Works, Licon Div.
355—Speed Measurement, 4 pp, Meriam Instrument Co.
356—Fans & Blowers, 147 pp, Benson Mfg Co, Dean & Benson Research Div.
361—Electrode Glands, 8 pp, Conax Corp.
364—Servoamplifiers, 16 pp, Siegler Corp, Magnetic Amplifiers Div.
366—Coated Insulation Materials, 6 pp, Minnesota Mining & Mfg Co.
368—Microminiature Relay, 1 pp, Filter Inc.
371—Inspection Lights, 4 pp, Welch Allyn Inc.

HYDRAULIC, PNEUMATIC EQUIPMENT
350—Filter Components & Assemblies, 32 pp, Screen Products Inc.
363—Line Strainers, 4 pp, OPW-Jordan Corp.
365—Control Valves, 8 pp, OPW-Jordan Corp.
369—Filter Regulator, 2 pp, Rockwell Mfg Co, Meter & Valve Div.

(please print or type) *If this is change of address, check box* ☐

Name..... Title.....

Street.....

City..... Zone..... State.....

Company..... Major Product Manufactured.....

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	316	331	346	361	376
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

REPRINTS
P51 P52 P53 P54 P56 P58 P59 P60 P61 P62 P64
P65 P66 P67 P68 P69 P70 P71 P72 P73 P74 P75

*MULTIPLE Key No.	PRODUCT ADS Specific Product

(please print or type) *If this is change of address, check box* ☐

Name..... Title.....

Street.....

City..... Zone..... State.....

Company..... Major Product Manufactured.....

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	316	331	346	361	376
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

REPRINTS
P51 P52 P53 P54 P56 P58 P59 P60 P61 P62 P64
P65 P66 P67 P68 P69 P70 P71 P72 P73 P74 P75

*MULTIPLE Key No.	PRODUCT ADS Specific Product

USE THESE PREPAID CARDS FOR

- More information on advertised products
- More data on new materials and components
- Copies of catalogs and bulletins offered
- Free editorial reprints
- Your personal subscription to PRODUCT ENGINEERING

Issue of December 26, 1960
PRODUCT
ENGINEERING
Card expires February 24, 1961

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

Postage Will Be Paid By Reader Service Department

PRODUCT ENGINEERING
330 WEST 42nd STREET
NEW YORK 36, N. Y.

22 FL

Issue of December 26, 1960
PRODUCT
ENGINEERING
Card expires February 24, 1961

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

Postage Will Be Paid By Reader Service Department

PRODUCT ENGINEERING
330 WEST 42nd STREET
NEW YORK 36, N. Y.

22 FL

Information Sent Promptly

An Opportunity To Get More Information Quickly, Conveniently

POSITIVELY

TOTAL QUALITY CONTROL

You get better, more uniform oil seals as a result of National's 4-part quality program

1. New Seal Design
2. Incoming Materials
3. In-Process Control
4. Quality Assurance

In these four separate areas National follows rigid quality control mandates.

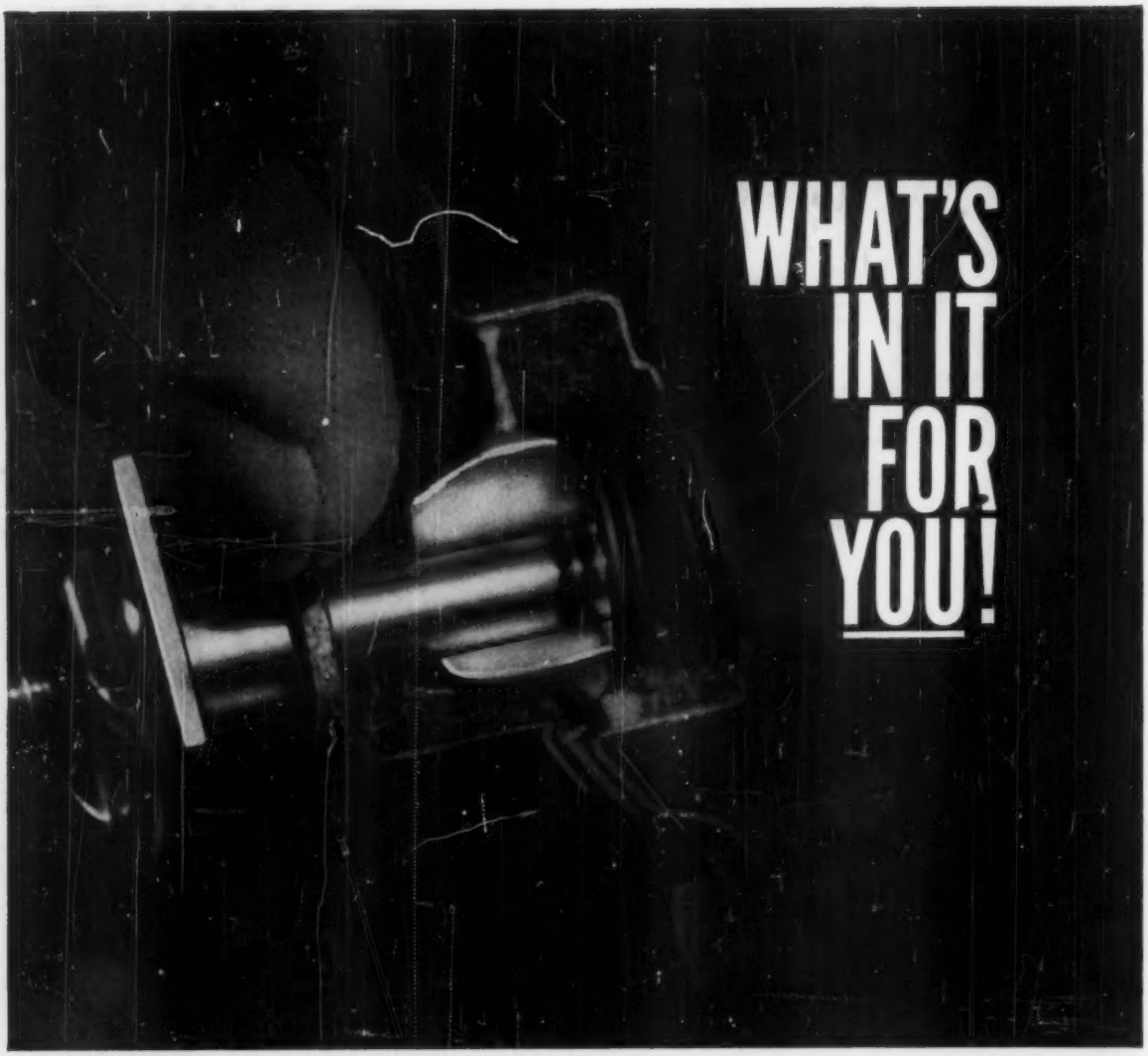
Quality Control Managers and teams reporting directly to National's General Manager work with Engineering to establish AQL's—Acceptable Quality Levels—for all new products. They supervise careful inspection of all raw materials in National Seals. They provide production inspection, monitoring performance of Manufacturing and developing new methods of in-process control. And finally, Quality Assurance, which is the periodic, random re-testing of production parts.

For dependability in seals, and the nation's finest oil seal engineering help, call your National Seal Applications Engineer (Yellow Pages under "Oil Seals") or write direct.

NATIONAL SEAL DIVISION, FEDERAL-MOGUL-BOWER BEARINGS, INC.
GENERAL OFFICES: Redwood City, California
PLANTS: Van Wert, Ohio; Redwood City and Downey, California

6858

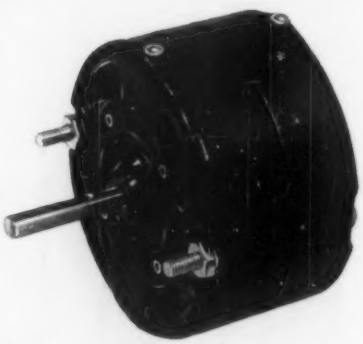
CIRCLE 202 ON READER SERVICE CARD



BEARING DESIGN OF
EMERSON ELECTRIC MOTORS

Is Self-Oiling, Self-Aligning to assure Free Starting and Smooth Operation at all times

—The bronze bearing in Emerson Electric Motors has thousands of tiny cells that cause the bearing to act as a metal sponge and feed the shaft journal a controlled flow of lubricant. In cooling, it draws off excess oil to give free starting at low temperatures. Self-Alignment minimizes friction and greatly increases motor life when you install *Emerson Electric Motors* in your appliances and equipment. Emerson Electric Motors are custom-engineered to meet your specific needs. Call us *today* . . . you'll like our way of doing business!



EMERSON ELECTRIC *of St. Louis • Since 1890*

DEPT. M21, 8100 FLORISSANT • ST. LOUIS 36, MO. • CO 1-1800

CIRCLE 203 ON READER SERVICE CARD